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WASTE PROCESSING MULTI-YEAR PROGRAM PLAN FISCAL YEAR 2008-2012

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I. Introduction

The Office of Environmental Management's (EM) Roadmap, *U.S. Department of Energy (DOE) – Office of Environmental Management Engineering and Technology Roadmap* (Roadmap), defines the Department's intent to reduce the technical risk and uncertainty in its cleanup programs. The unique nature of many of the remaining facilities will require a strong and responsive engineering and technology program to improve worker and public safety, and reduce costs and environmental impacts while completing the cleanup program. The technical risks and uncertainties associated with cleanup program were identified through: 1) project risk assessments, 2) programmatic external technical reviews and technology readiness assessments, and 3) direct site input. In order to address these needs, the technical risks and uncertainties were compiled and divided into the program areas of: Waste Processing, Groundwater and Soil Remediation, and Deactivation and Decommissioning. Strategic initiatives were then developed within each program area to address the technical risks and uncertainties in that program area. These strategic initiatives were subsequently incorporated into the Roadmap, where they form the strategic framework of the EM Engineering and Technology Program.

The Office of Waste Processing Multi-Year Program Plan (MYPP) supports the goals and objectives of the Roadmap by providing direction for technology enhancement, development, and demonstrations that will lead to a reduction of technical uncertainties in EM waste processing activities. The current MYPP summarizes the strategic initiatives and the scope of the activities within each initiative that are proposed for the next five years (fiscal year 2008 – 2012) to improve safety and reduce costs and environmental impacts associated with waste processing; authorized budget levels will impact how much of the scope of activities can be executed, on a year-to-year basis.

Waste Processing Program activities within the Roadmap and the MYPP are described in five strategic initiatives:

- Improved Waste Storage Technology,
- Reliable and Efficient Waste Retrieval Technologies,
- Enhanced Tank Closure Processes,
- Next-Generation Pretreatment Solutions, and
- Enhanced Stabilization Technologies.

These strategic initiatives were reviewed and accepted by the National Academies of Science committee that was empanelled to provide DOE-EM with strategic advice related to the Roadmap. The strategic initiatives were developed with input from the appropriate EM sites, projects, and programs in order to ensure that the key waste processing needs throughout the EM complex are fully represented in this effort. These initiatives and associated activities were developed by the Office of Waste Processing through an Initiative Development Team, formed with experts from national laboratories, private industry, and academia intimately familiar with the EM sites and programs that are involved with waste processing. Starting with the risks described in the Roadmap, the Initiative Development Team conducted an analysis of the risks and impacts if the risks are not mitigated. Additional information was gathered from reviews of external technical review documents, technology readiness assessments, project risk management plans, and the National Academies of Science review reports. In addition, stakeholder comments made on the original draft of the Roadmap were also reviewed. The Initiative Development Team then performed a gap analysis against current efforts funded by the EM sites, DOE programs, and other entities. Based on the results of this work, the team recommended activities within each strategic initiative area. The resulting list of activities represents an effort to develop a balanced research and development portfolio; one that addresses both near-term project needs, as well as the longer term strategic needs in waste processing. In developing this portfolio, an effort was made to leverage prior EM-funded development work, commercial capabilities and international expertise and experience. A more detailed discussion of technology leveraging is referenced in Section V of this document.

Comments received on the draft Roadmap document led to the recognition of the need to establish strategic initiatives in the areas of Spent Nuclear Fuel and Challenging Materials. These strategic initiatives will be incorporated into the next revision of the Roadmap, with planning activities and creation of Initiative Development Teams for both areas to occur during fiscal year 2008.

At the request of DOE-EM, the National Academies of Science empanelled a committee to assist DOE in developing the Roadmap and to make recommendations with regard to EM-directed research and development programs needed to help meet EM site cleanup challenges. Although this study is not yet complete (final report to be issued in February 2009), the committee completed site visits to Oak Ridge, Hanford, Idaho, and Savannah River, and has issued an interim report. The interim report makes the following observations and conclusions:

- The committee agrees with the five strategic initiatives identified for research and development investment in the Roadmap,
- The committee judges that a "significant, ongoing research and development program" is required in order for EM to meet all of its cleanup responsibilities,
- The committee feels that the EM Roadmap "can be an important tool for guiding DOE Headquarters investment in longer-term research and development," and

- The committee recognizes that the national laboratories at each of the major EM sites have special capabilities in science and technology that are important in addressing EM's site cleanup needs.

The Office of Waste Processing will be folding these National Academies of Science insights into the planning process for the fiscal year 2009 MYPP.

II. Mission and Vision

Mission
The mission of the Office of Waste Processing is to reduce the technical risk and uncertainty of EM waste processing programs and projects through the timely development of solutions to technical issues. The Office offers guidance and technical assistance to EM's waste processing operations and is responsible for the development of technology needed to address waste processing problems. Additionally, the Office of Waste Processing provides technical direction and/or assistance to sites to address difficult technical problems, sponsors cross-site integration and technology information exchange efforts, and provides engineering and scientific expertise for external technical reviews and technology readiness assessments to address difficult technical problems or for resolution of issues identified by project managers.

Vision
The Office of Waste Processing identifies and reduces engineering and technical risks associated with key waste processing project decisions. The risks, and actions taken to mitigate those risks, are determined through technology readiness assessments, program reviews, technology information exchanges, external technical reviews, technical assistance, and targeted technology development and deployment. The Office of Waste Processing works with other DOE Headquarters offices, project and field organizations to proactively evaluate technical needs, identify multi-site solutions, and improve the technology and engineering associated with project and contract management. Participants in this program are empowered with the authority, resources, and training to implement their defined priorities, roles, and responsibilities.

III. Needs for Reducing Technical Risk and Uncertainty for EM

EM is responsible for the cleanup of the environmental legacy of the Nation's nuclear programs. The waste processing portion of this mission encompasses the treatment and disposition of high-level liquid waste, and the transportation and disposal of low-level waste, and transuranic waste. Many of these wastes and facilities are unique to DOE, with the result that the programs to treat these wastes are "first-of-a-kind" and unprecedented in scope, complexity and/or technical difficulty. As a result, the technologies required to disposition these wastes often must be developed "from scratch" or require significant re-engineering to adapt to EM's needs. To address such technology needs, EM has established the EM Engineering and Technology Program. The Office of Waste Processing within the Engineering and Technology Program is focused on the technology that enables the reduction of risk and uncertainty for handling and disposition of high-level waste, low-level waste, and transuranic waste throughout the complex. Priority is given to the technical areas and the sites with the highest risk, but the Office of Waste Processing technology development efforts encompass all sites and all waste issues.

Development of technologies that enhance the safety, effectiveness, and efficiency of handling, treating and disposing of the legacy wastes addresses a very large challenge. The Department has approximately 95 million gallons of liquid waste stored in underground tanks and approximately 4,000 m^3 of solid waste derived from the liquid high-level waste stored in bins. The current DOE estimated cost for safe storage, retrieval, treatment and disposal of this waste exceeds $50 billion, to be spent over several decades. The challenges associated with high-level waste include:

- Safe storage – millions of gallons of high-level waste reside in underground tanks located at Hanford and Savannah River, with some waste also remaining at Idaho. Storage space is at a premium and the tanks themselves must be maintained in good condition.

- Waste retrieval – safe and effective methods must be developed for the retrieval and transport of the high-level waste material from the storage tanks. This is particularly challenging due to large differences in waste composition even between tanks at the same site.

- Tank closure – following removal of the high-level waste from storage tanks, the tanks must be cleaned to an appropriate level and closed. The tank closure process usually involves an assessment of the residual contamination followed by grouting to fix the contamination and place the tank into a safe and stable end state.

- Waste pretreatment – processes must be developed to efficiently separate high-level waste into low-activity and high-activity components; this reduces the amount of high-activity waste that must be processed and disposed. The development of pretreatment processes is especially difficult because of the differences in waste composition between tanks and sites. Pretreatment processes must be tailored to the waste composition and to the waste treatment process that will follow.

- Waste treatment/stabilization – processes must be developed to treat both the low- and high-activity waste fractions in order to render them into forms suitable for long-term disposal. In some cases, new treatment or stabilization processes must be developed for a particular waste stream; in other cases, an existing process can be modified to accept a new stream.

Opportunities for improvement in treating and disposing of this waste depend on several factors including revised approaches, new acquisition strategies, and revised cleanup agreements. This MYPP focuses on the development and implementation of new or improved technologies at the appropriate time in site program schedules. Timely recognition of the need for an improved technology or technical approach and the initiation of a focused technology development program are the keys to successfully accelerating waste treatment and disposition. Processing of high-level waste at the sites involves integration of many complex shared retrieval, processing, and immobilization issues. Through close interaction with EM site management, improved technical approaches for the highest cost high-level waste activities at each site can be developed and there will be opportunities to transfer technologies from one site to the other and achieve additional savings in schedule and cost.

The highly radioactive portion of this high-level waste at Hanford (Office of River Protection), Idaho, and Savannah River must be treated and immobilized, and prepared for shipment to a geologic waste repository. The Office of River Protection is currently building a Waste Treatment and Immobilization Plant to treat roughly 53 million gallons of high-level waste stored in 177 underground tanks. Idaho is committed to treating approximately 3 million gallons of liquid waste and transferring both the treated liquid and stored solid wastes to approved repositories. Savannah River has been processing tank sludge since 1996, gaining significant experience for the EM complex; however, a number of processing challenges remain. All of these sites have aggressive schedules for waste treatment and tank closures and will require the support of improved technology and approaches to meet or accelerate those schedules.

As a result of the importance of reducing technical risk and uncertainty in the EM Waste Processing programs, the Office of Waste Processing has focused considerable effort on identifying the key areas of risk in the Waste Processing programs. The resulting summary of technical risks and needs was captured in the Roadmap. The Roadmap identifies key Waste Processing initiative areas where technology development work should be focused. These areas are listed below, along with the Work Breakdown Structure (WBS) designation given to each initiative area. The WBS designations will be used throughout this document.

- Improved Waste Storage Technology (WBS 1.1)
    - Develop cost effective, real-time monitoring of tank integrity and waste volumes to ensure safe storage and maximum storage capacity.
    - Improve understanding of corrosion mechanisms and changing waste chemistry, including flammable gas generation, retention, release, and behavior to establish appropriate assumptions in safety analyses.
- Reliable and Efficient Waste Retrieval Technologies (WBS 1.2)
    - Develop optimization strategies and technologies for waste retrieval that lead to successful processing and tank closure.
    - Develop a suite of demonstrated cleaning technologies that can be readily deployed throughout the complex to achieve required levels of removal.

- Enhanced Tank Closure Processes (WBS 1.3)
  - Improve methods for characterization and stabilization of residual materials.
  - Develop cost-effective and improved materials (e.g., grouts) and technologies to efficiently close complicated ancillary systems.
  - Perform integrated cleaning, closure, and capping demonstrations.
- Next-Generation Pretreatment Approaches (WBS 1.4)
  - Develop in- or at-tank separations solutions for varying tank compositions and configurations.
  - Improve methods for separation to minimize the amount of waste processed as high-level waste.
- Enhanced Stabilization Technologies (WBS 1.5)
  - Develop next-generation stabilization technologies to facilitate improved operations and cost.
  - Develop advanced glass formulations that simultaneously maximize loading and throughput.
  - Develop supplemental treatment technologies.

Detailed discussion of each strategic initiative area and the proposed approach to technology development is provided below in Section IV.

Technical risks and uncertainties in the Spent Nuclear Fuel and Challenging Materials programs, discussed in the Roadmap, will be evaluated during fiscal year 2008, along with the appropriate strategic initiatives that describe the technology development needed to address those risks.

IV. Strategic Initiatives

The initiative areas listed in this section are identified in the Roadmap; they indicate technical challenges where development work is critical to reduce the key technical risks and uncertainties in the EM Waste Processing programs. Work in these initiative areas is expected to produce solutions and/or enable key decisions at one or more DOE sites facing a given risk.

Each of the five major Waste Processing strategic initiatives described in this section is identified by a title and a WBS number (e.g., *WBS 1.1, Improved Waste Storage Technology*). Within each major initiative area are several sub-level initiatives that provide more specific technical information on the needs within the overall strategic initiative. The sub-level initiatives are given a unique WBS number and title, e.g., *1.1.2, Improving Waste Tank Integrity Assessments.* Each sub-level initiative is further subdivided into multiple proposed tasks that are intended to address specific technical risks. These tasks are also identified with unique WBS number and title, e.g., *1.1.2.2, Carbonate/Aluminum Corrosion Studies to Support Double-Shell Tank Life Extension.* These tasks represent the proposed development work that was scored and prioritized as part of the development of this MYPP.

These initiatives and associated activities were developed from the Roadmap by the Office of Waste Processing through an Initiative Development Team formed with experts from the Office of Waste Processing, national laboratories, private industry, and academia intimately familiar with the EM sites and programs engaged in waste processing activities. (Appendix A shows the Initiative Development Team organization structure and leads). Starting with the risks presented in the Roadmap, the Initiative Development Team conducted an analysis of the risks and impacts, if not mitigated. The team then performed a gap analysis against current efforts funded by the EM sites, DOE programs, and other entities. Based on the results of this work the Initiative Development Team developed a list of recommended investments in the activities listed in the strategic initiative areas. The Initiative Development Team was assisted in this effort by NuVision Engineering and Different-by-Design, using a systematic prioritization and optimization process. (An overview of the process used is given in Appendix B). The resulting initial prioritized list of proposed tasks - the technology development portfolio - was then reviewed with EM site senior management to gather their input and comments. The Initiative Development Team then worked through the comments, corrected/updated the input to the prioritization process and worked with the Office of Waste Processing staff to develop a final recommended prioritized technology development portfolio that matches the available funding level for fiscal year 2008. The prioritized portfolio was reviewed to ensure a reasonable balance between:

- Near-term (quick win) accomplishments and more strategic tasks - those addressing long-term objectives,
- Tasks addressing technologies requiring a long development cycle and those near deployment, and
- A reasonable distribution of tasks across the WBS elements.

Appendix C provides a listing of all the tasks developed and considered for funding by the Initiative Development Team. The final proposed funding listing for fiscal year 2008 was produced after evaluating all inputs and undergoing a final review by senior EM management. This portfolio is found in Appendix D of this document. Appendix D compiles the listing of funded projects including those using carryover funding and selected projects from other funding mechanisms.

For each strategic initiative discussed in this section, a general overview of the technical issues is provided, followed by a description of each sub-level initiative within that strategic area. Each sub-level initiative description includes an overview of the specific need, a summary of the technology development approach for fiscal year 2008 and beyond, and the specific fiscal year 2008 tasks that are proposed to address that need.

WBS 1.1 Improved Waste Storage Technology

The initiatives in this area pertain to improved monitoring capabilities, improvements in tank integrity assessments, and improvements in understanding waste tank chemistry and behavior.

The goals of this initiative are to develop technical approaches and tools that allow waste tank integrity to be more accurately assessed and tank storage capacity to be safely maximized. Such goals may be achieved through the development of an improved understanding of waste tank chemistry and the development and application of improved monitoring tools for assuring tank integrity, and accurately determining waste volumes and physical/chemical characteristics.

1.1.1 Approaches for Increasing High-Level Waste Tank Capacity

Overview: Both Hanford and Savannah River sites are limited in available tank space to support waste operations and tank retrieval. This limitation is further constrained by assumptions in the safety bases for tanks aimed at mitigating the chances for exceeding the lower flammability limits for hydrogen. In this regard, the present state of information on actual waste behavior has resulted in models that can prevent optimized use of the available tank space. Similarly, the precision of present measurement technologies impacts fully-effective use of tank space.

Approach: Activities in this initiative will focus on the development of transformational numerical models for estimating gas retention and on the development of measurement technologies for quantifying critical waste properties. The modeling efforts will be supplemented and supported by laboratory testing for key properties. It is envisioned that the tasks in this initiative will involve private industry, national laboratories, and universities. Because of the potential applicability of commercial technologies, it is expected that this initiative will include the development of requests for information or vendor forums as a means of gathering broader input on potential technologies in this area. Formal requests for proposals may follow, as needed.

1.1.2 Improving Waste Tank Integrity Assessments

Overview: The high-level waste storage tanks at Hanford and Savannah River are critical national assets that must be maintained beyond their initial estimated design lives. However, it is difficult to determine the optimum measures to maximize the utility of the tanks and maintain their integrity due to incomplete understanding of the tank structural vulnerability and chemical corrosion mechanisms. Conservative assumptions have been put in place that preserves tank integrity; however, these assumptions can lead to less than optimal tank utilization.

Approach: Activities in this initiative will focus on developing an improved understanding of the chemical mechanisms that result in corrosion of high-level waste storage tanks and their ancillary systems, such that appropriate corrosion standards can be applied. This includes further development of in-tank corrosion probes and chemical sensors needed to support real-time decisions. Tasks planned for this initiative will involve private industry, national laboratories, and universities. The requests for information will be developed to solicit information on applicable commercial sensors, tools and a technique, with requests for proposals following (as needed). Other activities proposed include detailed finite element analyses that will be conducted on the tanks to establish the appropriate assumptions for waste limits. As well, an advanced fracture mechanics methodology will be developed to reduce the uncertainties and conservatism in the understanding of tanks with known flaws.

1.1.3 Improved Understanding of Tank Waste Chemistry and Behavior

Overview: Safe storage, management, and treatment of the DOE high-level nuclear waste inventory require a detailed understanding of its composition and reactivity. This information is difficult to obtain, given the complex composition of the wastes and further complicated by multiple transfers, evaporation campaigns, and aging that have created unique solids and liquids in each tank. As a result, site contractors are often forced to develop one-of-a-kind solutions for many waste operations.

Approach: Activities in this initiative will focus on developing and assessing models, tools, and analytical methods that can address critical compositional and operational challenges. The goal is to develop recommendations on models, techniques, and tools that will allow sites to apply consistent solutions to common challenges. The work will be accomplished through a mix of modeling activities, laboratory work, and applications of commercial technology. It is envisioned that the tasks in this initiative will involve private industry, national laboratories, and universities. Because of the potential applicability of commercial technologies, it is expected that this initiative will include the development of requests for information on tools, methods, and techniques for waste analysis and sampling, as a means of gathering broader input on potential technologies in this area. Subsequent to the requests for information, the requests for proposals will be developed as promising applications are identified. International experience and capabilities will be considered as well. The team will work with the major sites (particularly Savannah River and Hanford) to determine the priorities and timing for insertion of the appropriate technology.

WBS 1.2 Waste Retrieval Technologies

The initiatives in this area pertain to the development of methods that allow the retrieval of waste to the maximum extent practical for subsequent processing and treatment, followed by chemical cleaning of the waste tank prior to closure. Current waste removal and retrieval operations can be costly and are often limited by tank conditions. Complications include difficult-to-remove waste deposits, limited accessibility, and in-tank debris, etc. Also, inhomogeneous (i.e., different size, shape, and consistency) bulk waste retrieval could leave waste that is not acceptable for downstream processing due to size or composition. Additionally, a number of tanks are known or suspected to have leaked in the past; this may limit the use of current technologies that require significant water additions. Finally, improved mechanical and chemical retrieval technologies are also needed.

1.2.1. Develop a Suite of Residual Waste Removal Technologies

Overview: One of the primary aims of this initiative is to develop a "toolbox" of technology solutions to improve waste removal operations and remove the liquid and solids remaining in tanks and ancillary equipment after bulk waste removal operations are completed. This initiative will include identifying and developing the requirements and deployment strategies for multi-use adaptable concepts and technologies and identifying the gaps in existing DOE-sponsored and industrial technologies. Activities will include sampling and characterization during and prior to residual waste retrieval to assist with the efficiency of retrieval operation. Technologies and engineered solutions will be developed to remove radioactive material on the internal surfaces (walls, cooling coils, and other internal obstructions) and agglomerated materials that resist physical removal.

Approach: The general approach to this initiative involves a mix of the application of commercially available technologies along with the development of dedicated, specialized equipment. It is envisioned that the tasks in this initiative will involve private industry, national laboratories, and universities. Because of the potential applicability of commercial technologies, it is expected that this initiative will include the development of requests for information or vendor forums as a means of gathering broader input on potential technologies in this area. The requests for information (or forum) input will be evaluated and combined with a collection of lessons learned by a complex-wide team of technical experts. Industry experience will be utilized as much as practical. Industry tools will be integrated into overall deployable systems as appropriate. International experience and capabilities will be considered as well. The team will work with the major sites (particularly Savannah River and Hanford) to determine the priorities and appropriate timing for insertion of the appropriate technology. A method of communicating the status of the toolbox of technologies will be developed and communicated.

1.2.2 Develop Options for Chemical Cleaning

Overview: This initiative will develop a technology base to perform chemical cleaning, as required, following bulk and residual waste removal. The focus of these efforts will be to develop technologies that are suitable for deployment in tanks with significant obstructions and limitations on liquid addition. A major consideration in these development efforts is the downstream impact of chemical additions to the tanks.

Approach: An early task in this effort will be work on an integrated approach to tank cleaning that combines the tank cleaning requirements with consideration of tank integrity, downstream impacts, and limitations on liquid additions. This will be accomplished by gathering the information available to date from Savannah River, followed by Hanford, and reviewing with a team of experts. Further development work will include improving the understanding of the impact of chemical cleaning on the waste itself, including gas generation and speciation and fully understanding the impacts of the product of these efforts on downstream facilities and processes. Testing with real waste will also be performed.

WBS 1.3 Enhanced Tank Closure Processes

The initiatives in this area pertain to the effective characterization and stabilization of remaining material in waste tanks and ancillary systems once bulk waste removal has been completed. Following bulk, or even specialized retrieval operations for waste in underground tanks, some residual waste will remain. Because these residual materials and the associated limits play such an important role in the tank closure process, accurate and reliable methods for measuring the quantity and composition/radionuclide content of residual materials are important. The size and geometry of tanks, limited points of access and obstructions (cooling coils and other tank components) make accurate residual waste measurements difficult. New techniques and/or technologies will enhance the ability to make accurate and reliable measurements. Waste classification (either under DOE Order 435.1 or under Section 3116 of the National Defense Authorization Act) is an integral part of the closure process at all sites and requires immobilization of the radioactive waste residues in the tanks. Cementitious materials (grout) are used worldwide to immobilize low-level waste and have been chosen by DOE for tank closure applications. These materials are also planned for closure of ancillary equipment (such as pumps, valve boxes, and underground transfer lines). Formulations for these grout materials that provide the necessary chemical and physical properties (including aging properties), and that can be deployed in difficult to access locations, are necessary.

Tank Closure is a relatively new initiative and part of the effort in this area during fiscal year 2008 will be to further develop the critical needs, so that plans can be modified appropriately.

1.3.1 Improved Residual Tank Waste Characterization and Stabilization

Overview: This initiative will develop improved materials for stabilization of residual tank waste. This initiative will also develop sampling and analysis methods to assess the quantity, composition, and radioactive activity of residual tank waste in preparation for tank closure. Such assessments are often limited by difficult-to-access tanks, tank obstructions, poor lighting, etc.

Approach: A major portion of this initiative will focus on development of improved materials for stabilization of residual tank waste. Some work has been performed in this area and two tanks have been closed at the Savannah River site. However, the availability of certain grout property data that is important for support of performance assessments is limited. In particular, a better understanding of leaching and permeability of grouts will directly impact grout formulation efforts. Improved methods to collect this data will be developed and a database of information generated that will support formulation efforts.

The development of tools and techniques for stabilizing or fixing contamination in ancillary equipment during tank closure operations will also be a focus area for this initiative.

Longer term tasks in this initiative area will be related to sampling and analysis tools and techniques. Activities may include a definition of requirements for the accuracy needs of these sampling and analysis methods along with test requirements prior to deployment. The results of these efforts will be evaluated along with a collection of lessons learned, results of workshops, etc., by a complex-wide team of technical experts. Industry experience will be utilized as much as practical. Industry tools will be integrated into overall deployable systems, as appropriate. International experience and capabilities will be considered as well. The team will work with the major sites (particularly Savannah River and Hanford) to determine the priorities and appropriate timing for insertion of the appropriate technology.

1.3.2 Develop Materials and Technologies to Close Ancillary Systems

Overview: This initiative will focus on developing requirements and strategies for closing ancillary systems such as cooling coils, transfer lines, pump pits, etc. These areas are often very difficult to access and little is known about their current condition. To date, minimal effort has been placed on this part of the overall tank closure effort. Focus will be placed in the early years on further defining needs and requirements.

Approach: An early activity in this area will be to convene an expert panel through a workshop or other means to discuss the needs and requirements for closing these systems. Work on methods for characterizing residual material inside pumps, coils, transfer lines, etc., will be initiated. It is envisioned that the tasks in this initiative will involve private industry, national laboratories, and universities. Because of the applicability of commercial technologies and experience in this area, this initiative will include the development of requests for information or vendor forums as a means of gathering broader input on potential technologies in this area. Commercial tools and capabilities will be integrated into overall deployable systems as appropriate. International experience and capabilities will be considered as well.

Work will also be initiated to develop grout formulations that can be deployed over long distances (cooling coils, transfer lines, etc.) while still maintaining acceptable properties. This effort can be leveraged with work described as part of 1.3.1.

1.3.3 Perform Integrated Cleaning, Closure, and Capping Demonstrations

Overview: This initiative is not proposed to be worked in fiscal year 2008; however, planning will commence for a fiscal year 2009 start with the development of a set of requirements for performing integrated demonstrations. Input from the various impacted sites, as well as evaluation of results from fiscal year 2008 work in the Waste Processing and Groundwater and Soil areas will be considered. Funding for anticipated planning efforts will be derived from existing, planned Office of Waste Processing program management funding.

WBS 1.4 Next-Generation Pretreatment Solutions

The initiatives in this area encompass the identification and development of technologies that allow pretreatment of liquid waste in order to reduce the amount of waste processed and disposed as high-level waste. A significant impact can be made in cost and risk-reduction in the treatment and disposition of high-level waste through development of innovative technical approaches that improve baseline treatment technologies, yield alternative treatment approaches, or add supplemental treatment options to allow parallel processing (and, therewith, lifecycle cost reductions). The goal of this initiative is to develop such pretreatment technologies for applications that maximize the reduction of technical risk. Particular attention will be given to technologies that offer multi-site benefit.

1.4.1 Develop In- or At-Tank Separation Solutions

Overview: The purpose of this initiative is to develop engineering and technology for separating low-level waste from high-level waste fractions and removing solids from these solutions as required; a key transformational aspect of this initiative is to locate the treatment technology in- or at-tank. This requires re-examination of process flowsheet options and engineering solutions to closely couple the waste retrieval with pretreatment. Additionally, a goal is to develop tailored process flowsheets, for varying tank conditions and compositions, which provide flexibility and functionality for the pretreatment technology.

Approach: A key component of the approach to this initiative is to leverage existing Office of Waste Processing funded projects for in-tank treatment for transuranic, strontium, and cesium, while evaluating developing needs from the EM sites. Tasks funded under this initiative will use a mix of national laboratory, university and industrial assets and expertise, as appropriate, to develop treatment options and improve and optimize the processing flowsheets. Private sector input will be solicited through requests for information, with requests for proposals following (as appropriate).

1.4.2 Develop Improved Methods for Waste Separation

Overview: The purpose of this initiative is to develop engineered solutions that more effectively separate inert materials and low-activity waste from high-level waste, such that only the high-level waste fraction is stabilized for geological disposal. Among the key challenges being addressed at this time is the development of technology solutions that would allow for the removal of large amounts of aluminum from high-level waste sludge at Savannah River and Hanford in order to reduce the burden on the high-level waste vitrification facilities. Additionally, a significant fraction of predicted sludge batches at Hanford are limited by the chromium content. Technologies are needed to advance the understanding of chromium-oxidants and their impact on downstream processing.

Approach: This initiative will leverage on-going efforts for the development of treatment technologies for the removal of aluminum and chromium from high-level waste sludge. The approach will center on developing the science and engineering required to support the processing flowsheets. Resources at the national laboratories will be utilized, along with assistance from other sources such as universities and commercial/industrial corporations through requests for information/requests for proposals.

WBS 1.5 Enhanced Stabilization Technologies

The initiatives in this area are focused on applied research in all aspects of the waste immobilization processes (e.g., vitrification). Improvements have a multi-site benefit and yield significant cost savings and reduction of risk (technical and schedule). Alternative or improved melter designs may enable operations at elevated temperatures and higher throughput in the same plant footprint. Improved glass formulations that allow a higher waste loading would reduce the number of waste packages and improve throughput, both of which have significant benefits. Incremental gains could benefit current processing activities, while exploratory work on future wastes would also be used in planning activities and step function improvement in efficiency and reduction of programmatic risk. An overall loading improvement of a few percent could shorten the waste processing schedule by over a year and provide substantial cost savings. Additionally, there are some wastes that are not appropriate for vitrification. For these wastes, supplemental treatment operations are needed.

1.5.1 Develop Next-Generation Melter Technology

Overview: The purpose of this initiative is to develop alternative technologies for glass melting and melter operation that will permit higher melter throughput and/or increased waste loading. Waste glass melter throughput is determined by a number of interdependent parameters. To increase melter throughput these parameters must be considered and optimized specifically for the waste and facility to enable higher glass production rates. The loading of waste in glass is controlled in part by the melter processing related parameters. Certain melter design changes could yield improved loading of Savannah River high-level waste in glass, Hanford high-level waste in glass, and Hanford low-activity waste in glass. These design features can be developed and tested for optimal waste throughput at the three facilities.

Approach: A research and engineering program has been planned to systematically evaluate key melter design parameters for improved melting rate, enhanced waste loading, and acceptable or improved service life. A dual-path approach will be implemented: 1) improvements on current designs to achieve moderate improvements in waste throughput (~ 25 percent) with low risk and easy implementation, and

2) transformational-melter technology changes to achieve step function improvements in waste throughput (>30 percent) with higher risk and/or more complicated implementation as a strategic investment. In addition to melter enhancement, facility enhancements are often required to recognize the benefits of improved waste throughput. Tasks aimed at improvements to melter feed systems, canister handling systems, and decontamination systems are also considered.

These efforts will include the development of requests for information with an evaluation of this input along with a collection of lessons learned by a complex-wide team of technical experts. Industry experience will be used as much as practical. International experience and capabilities will be considered as well. The team will work with the major sites (particularly Savannah River and Hanford) to determine the constraints, priorities and appropriate timing for insertion of the improved melter technologies.

1.5.2 Develop Advanced Glass Formulations

Overview: The purpose of this initiative is to improve the existing glass formulation by increasing waste loading and waste throughput. This, in turn, would reduce the life cycle cost of waste processing operations and/or the number of glass canisters that must be disposed of. In addition, this initiative will refine the predictive models used for operation of the waste processing facilities to allow for enhanced operational control and improved life-cycle management by integrated storage, retrieval, pretreatment, and stabilization system optimization.

Waste loading is controlled by a number of chemical factors and can be controlled by the type and amount of additives mixed with the waste to form melter feed (e.g., frit at Savannah River and mined minerals at Hanford). Loadings are practically limited by key glass/melt parameters such as crystal or salt accumulation in the melter, melting rate, and chemical durability constraints, or by restrictions to remain within well-tested glass compositions regions. To increase loading, data must be collected to expand the composition regions, and better define the impacts of chemistry, and melter operation on the limiting parameters. Testing of glasses must be performed over a range of scales from small crucible testing to pilot scale melters.

Melting rate is controlled by a number of key melter parameters in addition to the feed chemistry. Relatively small changes in melter feed chemistry have been shown to impact melting rate by nearly 100 percent. To optimize glass formulations, predictive models capable of estimating the impact of feed chemistry on melting rate need to be developed applied.

Approach: A research program has been planned to accomplish increases in waste throughput at Hanford and Savannah River. The program will systematically evaluate key waste glass parameters, develop glass data for expansion of composition regions, and integrate with advanced melter technology development.

Both domestic and international experience and capabilities will be used for the best benefit of DOE. As the tasks to perform in this initiative are highly integrated with the melter development initiative and between tasks within the advanced glass formulation initiative, a team of experts from the national laboratories, and academia will be assembled to perform the research. The team will work with the major sites (particularly Savannah River and Hanford) to determine the priorities and appropriate timing and formulation direction throughout the research.

1.5.3 Develop Supplemental Treatment Processes

Overview: The objective of this task is to develop and demonstrate technology for the immobilization of secondary waste streams from the major EM sites. Several streams are to be considered, including: 1) excess pretreated low-activity waste from Hanford, 2) pretreated salt wastes from Savannah River, 3) Melton Valley tank wastes from Oak Ridge National Laboratory, 4) secondary wastes from tank farm and vitrification plant operations at Savannah River, Hanford, Idaho National Laboratory, and Oak Ridge National Laboratory, and 5) calcine and sodium bearing wastes at Idaho National Laboratory. It is critical to address these secondary waste streams as an inability to safely dispose of these streams can limit the deployment and/or utility of the primary waste treatment processes that they support.

Approach: Studies in support of supplemental treatment of Hanford low-activity waste will include advancements to the effectiveness and risk reduction for the bulk vitrification process. In addition, limited studies on alternate bulk vitrification concepts and alternate processes for treating excess Hanford low-activity waste will be considered. Studies in support of the Savannah River site salt waste treatment include advanced grout formulations, process control approaches, and qualification approaches. A treatability study of Melton Valley tank waste will be performed to demonstrate that a broader range of disposal paths are possible. Low temperature immobilization forms will be developed and demonstrated for secondary wastes from the four sites to include tank farm and treatment plant operation wastes. Backup treatment technologies will be investigated for Idaho National Laboratory calcine and sodium bearing wastes.

A research and demonstration program has been planned to lower the risk and improve the efficiency of waste treatment activities for these streams. The program will systematically evaluate improved treatment approaches and advanced flowsheets for the current treatment approaches. These efforts will include the development of requests for information with an evaluation of this input along with a collection of lessons learned by a complex-wide team of technical experts. Industry experience will be used as much as practical. International experience and capabilities will be considered as well. The team will work with the major sites to determine the priorities and appropriate timing for insertion of waste treatment technologies.

V. Leveraging – Moving Towards a Community of Practice

Leveraging of technology development has been a consistent priority since the inception of EM in 1989. For the purpose of this plan, leveraging involves closely monitoring technological advances in related programs and fields and determining opportunities for adoption within the Office of Waste Processing. The Office of Waste Processing continues to view leveraging as an integral component in the pursuit of the technology development goals outlined in this MYPP. As in the past, the opportunities for leveraging will take many forms. The following sections discuss leveraging opportunities:

- **National laboratories:** These laboratories are adjacent to the primary EM sites of Savannah River, Hanford, Oak Ridge, and Idaho, facilitating close integration between major EM projects and these laboratories. From their close ties to those sites, as well as their missions, capabilities and expertise, these laboratories are well suited to do technology development work related to the EM mission. The national laboratories will serve several roles in this plan. They will serve as technology developers for tasks which leverage their capabilities and experience. Due to the stringent requirements associated with high-level waste work, they will often serve as integrators and testers for technology developed by others. Through the active participation in planning the MYPP, the national laboratories will be able to leverage other work being performed at each institution.

- **Interface with Global Nuclear Energy Partnership:** The Global Nuclear Energy Partnership program is faced with many of the same technical risks and uncertainties as the Waste Processing program area. The DOE Office of Nuclear Energy is a key participant in the Global Nuclear Energy Partnership program. The Office of Waste Processing maintains an interface with the Global Nuclear Energy Partnership program to share lessons learned and to leverage funding to develop solutions to common technical challenges and in working to expand this collaboration. In addition, the four laboratories discussed above are Global Nuclear Energy Partnership participants; this work supports capabilities and lines-of-inquiry important to the Office of Waste Processing interests.

- **Private industry:** It is anticipated that important parts of the technology development work planned in this document will be performed by, or in conjunction with, private industry. There are a number of initiative areas where commercially available technologies are expected to be readily deployed to address the key issues. In additional cases, it is expected that the requests for information will be issued to obtain mature or nearly mature commercial technologies; this plan calls for formal requests for information to solicit such information in a timely fashion. The application of available commercial technologies requiring only minor modification or development is an effective way to address important EM program needs. To further leverage private industry, the DOE Advanced Remediation Technology program solicited proposals from industry to help address key EM clean-up issues. Late in fiscal year 2007, contracts were awarded to development of five technical proposals. Four of those proposals are in the waste processing area; they provide information and technologies that directly support this MYPP.

- **Academia:** Universities and associated institutions will continue to play an important part in the development of technologies for application to EM's technical issues. The implementation of a number of the proposed tasks draw upon university expertise in areas such as modeling and melter technology. Efforts in this area can normally be expected to result in deployable solutions in three - five years. In addition, these institutions provide the Office of Waste Processing and field offices with immediate access to world-class, independent expert technical assistance.

- **Basic science:** The role of the EM Engineering and Technology Program is to develop deployable technology solutions to address the key risks across the EM complex. As such, the EM Engineering and Technology Program does not conduct basic science research, such as that sponsored by the Office of Science. The Office of Waste Processing also stays abreast of basic science research through its connections with work at universities and national laboratories, as well as through participation in professional society conferences and meetings. In addition, the Office of Waste Processing and DOE Office of Science interface on a regular basis in areas of shared interest.

- **Workshops, conferences, and technical exchanges:** These venues provide valuable opportunities for sharing technologies, lessons learned, and best practices among people working in the same or similar fields. The Office of Waste Processing continues to pursue these leveraging opportunities by sponsoring technical exchanges and workshops in key initiative areas, by supporting attendance and participation in other workshops and conferences. These also present opportunities to bring EM issues to the attention of a broader scientific audience. This can result in new ideas and can help bring new researchers into the associated scientific fields. The Office of Waste Processing will also continue to encourage informal communications, exchanges, and contacts that help share or advance knowledge and experience.

- **International program:** EM in general and the Office of Waste Processing in particular continue to actively explore the use of international technologies for problems and issues in the complex. This includes regular discussion of the EM program and some of its needs at international symposia and through technical exchanges with several foreign entities (e.g., Russia, United Kingdom, France, South Korea, Germany, and Japan). These interactions have resulted in promising technologies (such as Cold Crucible Induction Melter), that are presently being demonstrated and have provided valuable data to support current operations (e.g., parameters important to continuous melter operations).

- **Nuclear Safety Research and Development:** The Defense Nuclear Facilities Safety Board issued its Recommendation 2004-1, Oversight of Complex, High-Hazard Nuclear Operations, on May 21, 2004. In its recommendation, the Defense Nuclear Facilities Safety Board noted concerns regarding a number of safety issues, including delegations of authority for fulfilling safety responsibilities, federal technical capability, central technical authorities, nuclear safety research, and lessons learned from significant external events, and integrated safety management. To resolve issues identified with nuclear safety research, DOE has established the Nuclear Safety Research and Development Coordinating Group; several primary functions of this group include: coordinating Nuclear Safety Research and Development activities across the DOE complex, ensuring that those activities support DOE's commitment to Integrated Safety Management, reporting on progress of Nuclear Safety Research and Development efforts and disseminating the results of Nuclear Safety Research and Development. The Office of Waste Processing is a member of the Nuclear Safety Research and Development Coordinating Group and has verbally briefed the prioritization process used in this MYPP and the important role that Environment, Safety, and Health plays in the prioritization to that group. Insights shared as part of the Nuclear Safety Research and Development Coordinating Group will be shared with the appropriate Initiative Development Teams. In addition, progress on safety significant tasks in this plan will be reported to the Nuclear Safety Research and Development Coordinating Group at least once per year.

- **Towards a community of practice – high-level waste or nuclear chemical engineering.** As is clear from the above discussion, the Office of Waste Processing community has always placed a high value on communications. A tool that has been developed, over the past several years, to improve communications among work groups is a concept called "communities of practice." This concept has been defined as follows: "A group of people who share a common interest in a subject or problem and who collaborate over an extended period to share ideas, find solutions, and build innovations (Wikipedia)." The Office of Waste Processing community has acted like a community of practice previously and will work to increase shared information and level of collaboration by formally embracing the community of practice concept and structure during fiscal year 2008.

VI. Administration of the Program

The overall leadership for the Waste Processing Technology Development Program is provided by the Director of Waste Processing, assisted by a team composed of the Initiative Development Team Lead, a Deputy Team Lead, advisory representatives from selected national laboratories, and the Office of Waste Processing Initiative Leads (see Appendix A).

The Waste Processing Initiative Development Team, under the management and technical direction of the Office of Waste Processing, provides technical leadership, program integration, and innovative thinking to the Technology Development Program. The Waste Processing Initiative Development Team is composed of Initiative subteams that have assigned responsibilities for developing and managing specific strategic initiative areas of the Roadmap. These subteams are made up of technical experts from the primary EM support national laboratories, academia, and private industry. Each Initiative subteam has an Initiative Technical Lead and a Federal Initiative Manager assigned to oversee and manage the work within the appropriate subteam for that initiative.

In fiscal year 2008, the new strategic initiatives in Spent Nuclear Fuel and Challenging Materials will be formally incorporated into the Roadmap and the appropriate Initiative Development Teams will be created. The planning and management responsibilities for these initiatives will reside in the Office of Waste Processing.

As an ongoing program, the Waste Processing Technology Development Program will provide key programmatic functions such as reporting, communications with outside organizations, and programmatic budget management. The Office of Waste Processing, assisted by the Initiative Development Team, will conduct reviews and provide budget and technical reports on development projects to EM. The Office of Waste Processing and the Initiative Development Team will also actively communicate with site field representatives and contractor personnel on the results of development work and, in the course of these discussions, the need for new initiatives. Scheduled reviews and reports are described in Section VII below.

Administrative functions required to support the program will be scaled to support the technology development funding level received. Depending on the funding level obtained for technology development tasks, a small dedicated program support staff – including administrative assistants, financial analysts, and procurement engineers – may be employed to support the work. To provide these functions, the Office of Waste Processing will leverage resources from all the supporting national laboratories, but will primarily be assisted by the Savannah River National Laboratory in its role as the EM's Corporate Laboratory.

VII. Technical Oversight and Review

The Office of Waste Processing has established a review structure that will ensure the work proposed in this MYPP is targeted to maximize the risk reduction at the EM sites, performed successfully, and that it met the overall needs of the program. Oversight of the program will be ongoing and will be managed by the Office of Waste Processing with knowledgeable input and assistance from the Waste Processing Initiative Development Team.

Review activities will support real-time management of the technology development portfolio. The focus of the management and direction of the Technology Development Program will be real-time interaction among the Principal Investigator, the Initiative Lead, and Initiative Manager. This real-time interaction will be facilitated by a monthly report, authorized by the Principal Investigator, distributed to the Initiative Lead and Initiative Manager electronically, and timed to accommodate the inclusion of up-to-date technical and financial information. The individual Principal Investigator reports will be consolidated by the Initiative Lead, along with any commentary deemed appropriate, and distributed to the Initiative Development Team and the Office of Waste Processing (copy to other Initiative Leads and Initiative Managers). In quarters that do not involve the Mid-Point or Annual Reviews, discussed below, the Initiative Lead's and Initiative Manager's will coordinate a quarterly review of the progress in the initiative area. The results of this quarterly review will be summarized and report to the Initiative Development Team. At approximately the mid-point of the year, the Director of Waste Processing will hold a Mid-Year Review of funded projects. This review will involve the Principal Investigator's, the Initiative Lead's, Initiative Manager's, and representatives from the major EM sites/projects; it will cover technical results, financial progress, highlight issues, program ties, and successes. This review will also provide the information necessary for the Office of Waste Processing to make decisions about any needed adjustments in the portfolio of funded projects.

Later in the year, the Office of Waste Processing will begin planning for the next budget year by:

- Reviewing anticipated budget scenarios,
- Soliciting input on potential new tasks from site representatives and the Initiative Teams, and
- Holding a Year-End Review to update the status of currently funded work.

All of this input will be used to support the annual Initiative Selection and Prioritization Review, where the proposed technology development portfolio for the upcoming budget year will be developed.

In addition to the programmatic reviews, the Office of Waste Processing will schedule External Technical Reviews of the technical status of several key development projects each year. The exact selection and timing of projects to be reviewed will be made by the Director of Waste

Processing, with approximately three External Technical Reviews will be conducted each year. Typically, an External Technical Review will be performed on a project as it transitions to a state of higher technical maturity.

The Office of Waste Processing will also invite other Federal Agencies and offices to view the progress of the work and to provide input on how work going on within their agencies can be used to assist EM. This Annual Office of Waste Processing Technology Demonstration Program Review will involve all technology providers including national laboratories, universities, industry, and international projects that impact the mission of EM. This will allow good cross-fertilization within the program.

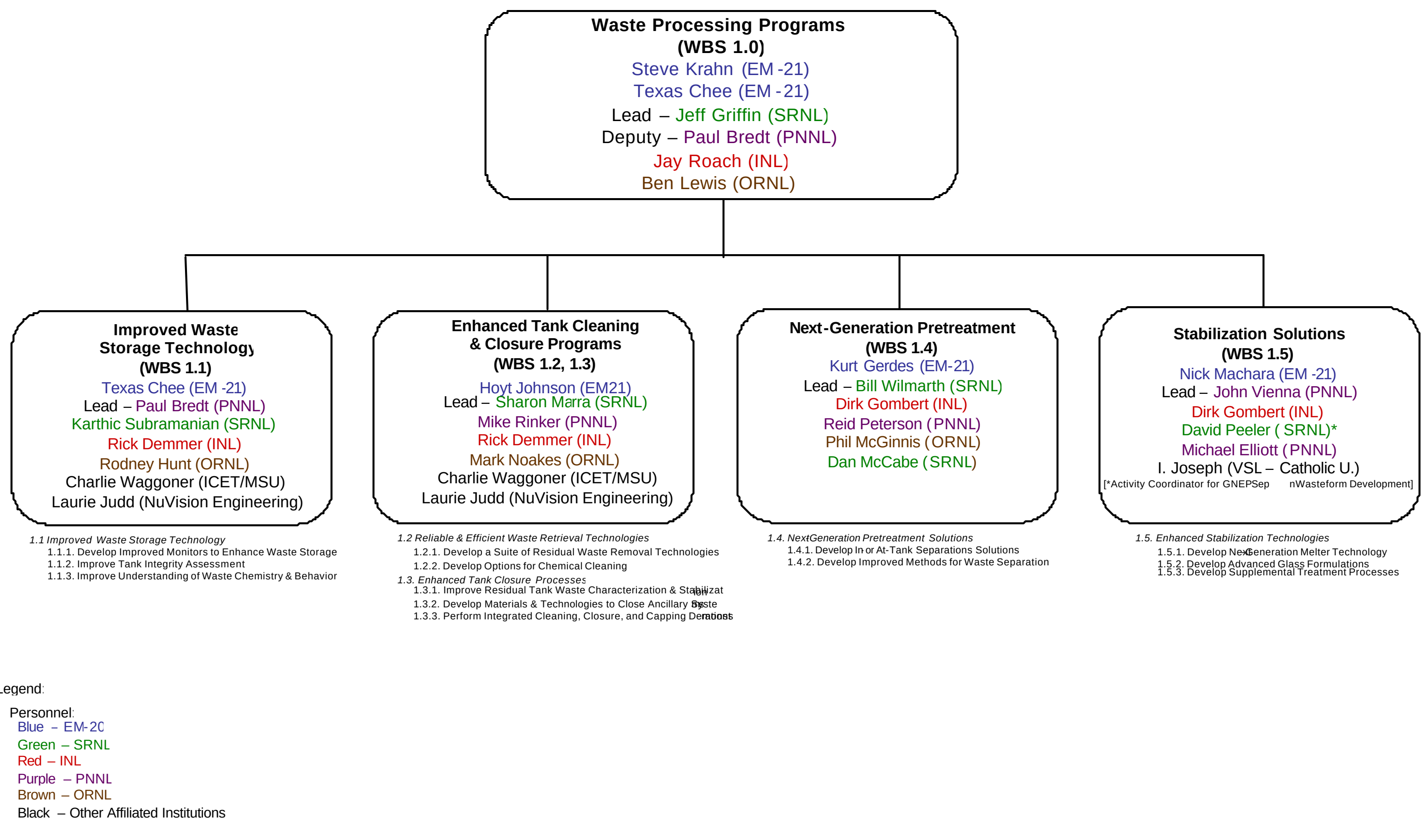
Table 1, below, provides a summary of the planned Waste Processing Program reviews and their anticipated timing.

Table 1. Planned Waste Processing MYPP Reviews

Activity	Participants	Schedule
Status updates	Leads with Principal Investigators Leads, Federal Strategic Initiative Managers	Monthly
Quarterly Program Review	Federal Strategic Initiative Managers	Quarterly
Mid-year progress review of funded projects	Office of Waste Processing, Initiative Development Team, Leads, Federal Strategic Initiative Managers, Principal Investigators	July
MYPP Revision planning	Leads, site representatives, Federal Strategic Initiative Managers	July
New Start Input	Federal Strategic Initiative Managers	July
Initiative Selection and Prioritization Review	Office of Waste Processing, Full Team	August
External Technical Reviews for Maturing Programs	Leads, Principal Investigators, Federal Strategic Initiative Managers	Technologies and schedule as selected by the Office of Waste Processing and Initiative Development Team
Annual Waste Processing Program Progress Review	Office of Waste Processing, Initiative Development Team, Full Team, Office of Science, Office of Nuclear Energy, Site Representatives, and others	Annually

Appendix A

Waste Processing Programs



Appendix B

Introduction

In order to provide a structured, transparent, auditable, and defensible Technology Development and Demonstration program, the Office of Waste Processing implemented, as a pilot project, a process known as D_2O to prioritize its portfolio of proposed projects. The D_2O process has been used successfully in the United Kingdom environmental management program and provides a systematic approach to identifying tasks, evaluating those tasks against agreed criteria, and developing the most efficient portfolio of projects that maximizes benefit to the EM program and mission within available funding limitations. The D_2O process is described briefly in this appendix.

The D_2O Prioritization Process

The D_2O prioritization process is a sequential series of 12 steps as depicted in Figure B. 1 and described in the text below. For clarity, iterative process flows are not depicted in Figure B. 1; however, as the process progresses, iteration is encouraged and facilitated to ensure a robust result.

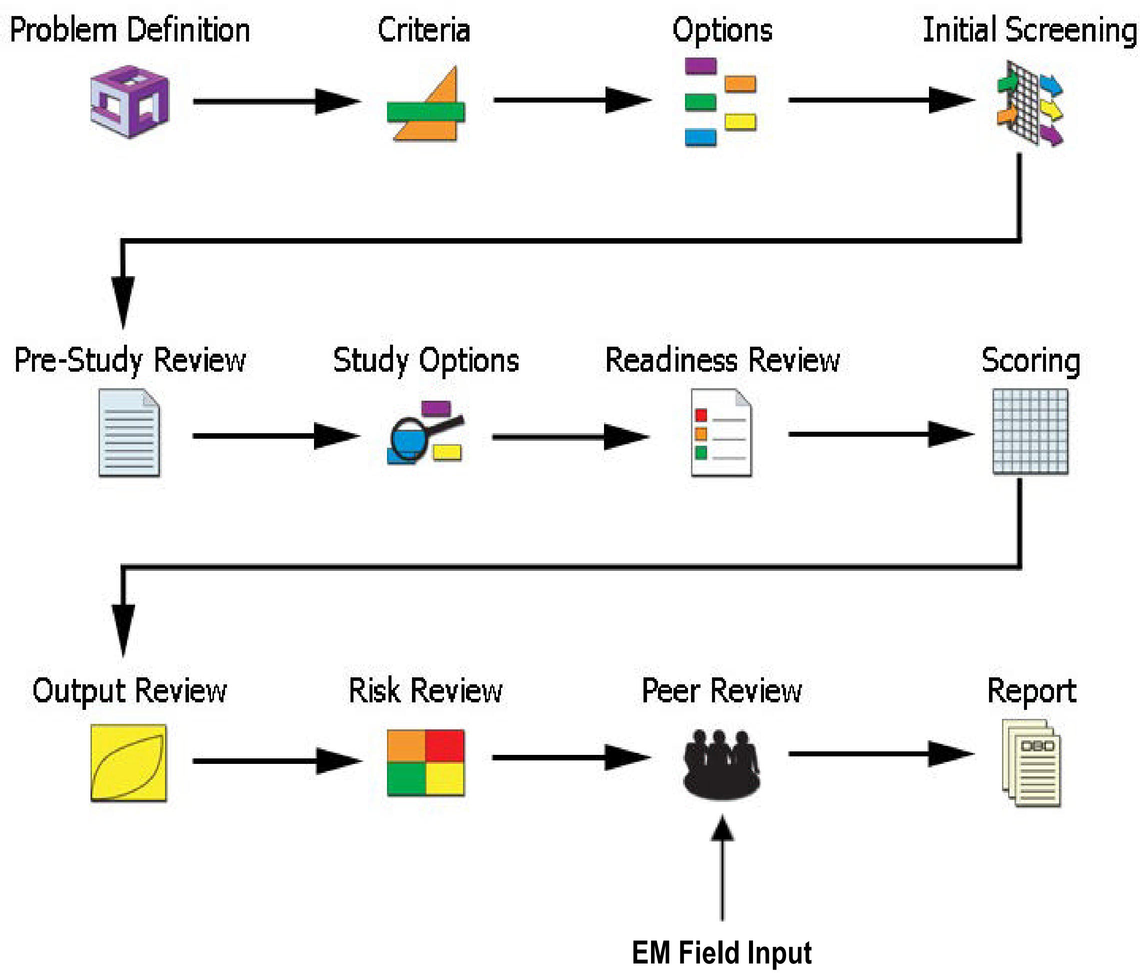


Figure B. 1: The 12 Steps of the D_2O Prioritization Process

Step 1 – Problem Definition: Essential background information and documents for the project were collected and reviewed during this step. This included the EM mission and the *U.S. Department of Energy – Office of Environmental Management Engineering and Technology Roadmap* (Roadmap).

Step 2 – Criteria: The criteria are the factors that differentiate between the proposed tasks and which are considered in order to develop a priority level. These criteria, shown below in Figure B. 2, were specifically developed to enable scoring of tasks based on the degree to which they support the objectives of the Roadmap. The criteria were initially developed collaboratively by staff from DOE, national laboratories, and contractor personnel and then reviewed on an ongoing basis.

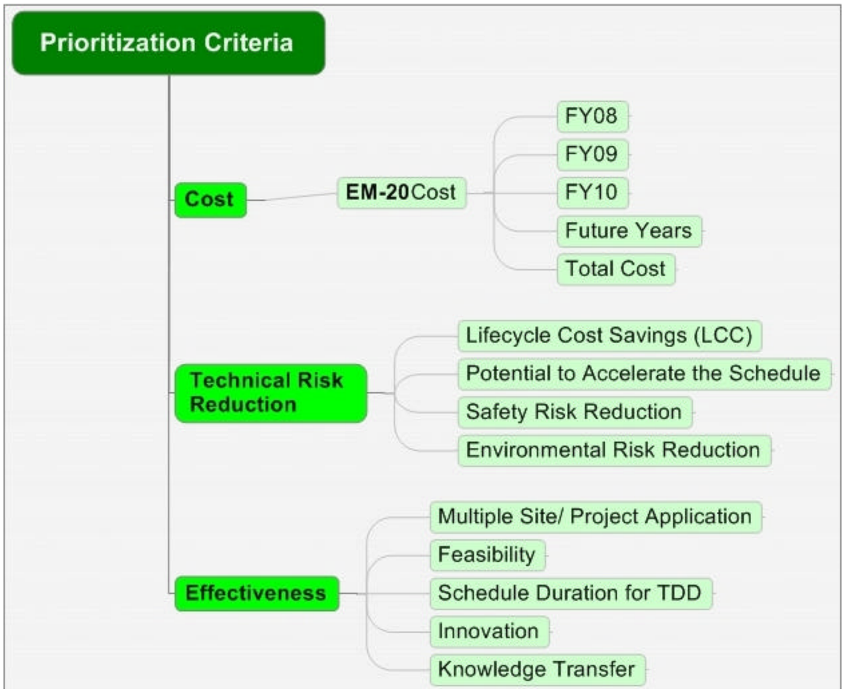


Figure B. 2: Criteria Used for the Waste Processing Technology Development and Demonstration Program Prioritization

Step 3 – Options (Tasks): For the Waste Processing program prioritization, the options are the Technology Development and Demonstration Program tasks, which could benefit projects across the DOE complex. In this case, tasks identified and data collected at the October 2006 Technical Integration Workshop were used as initial inputs to the process. In all, 141 tasks were identified across the five WBS elements.

Step 4 – Initial Screening: Typically, tasks that are deemed unreasonable or that can be excluded based on information known to participants in the project are removed at this step. This step yields efficiency by reducing the overall number of relevant options in consideration. During the waste processing prioritization the total number of tasks was refined from 141 to 122.

Step 5 – Pre-Study Review: A detailed data collection template based on existing Technology Development and Demonstration Program templates was developed and agreed by the team. This enabled the prioritization team to begin collecting the data which would be fed into the scoring process. The data requirements were both qualitative and quantitative depending on the criteria and required a combination of expert judgment and detailed assessment.

Step 6 – Study Options (Tasks): The data associated with the prioritization effort was collected during this step. The data from the October 2006 Technical Integration Workshop was reviewed, updated, validated, and expanded based on the data collection template requirements. The data was extracted from the collection templates and merged into a central file.

Step 7 – Readiness Review: In this step, the received data was reviewed for completeness and consistency by the prioritization team. The quality of the data was documented and additional requests for data or clarification were made.

Step 8 – Scoring: In this step, the data was transferred from the data warehouse into the D_2O prioritization tool by the prioritization team. The tool was used to produce summary outputs of the data, for review with participants at a scoring workshop.

Step 9 – Output Review: Following review of the scores for each task, the first draft prioritized project portfolio was reviewed and the leading portfolio of projects was identified. Analysis of the drivers behind the tasks, differentiators between leading tasks/portfolios, and stakeholder preferences were conducted. Program participants evaluated the portfolio against expert judgment to determine if the process had adequately captured the most important criteria and scaled the criteria correctly. This review led to adjustment of the scope of some tasks to more closely align them with the Roadmap.

Step 10 – Risk Review: The portfolio was examined in light of risks involved with completing the prioritized portfolio of projects. This included evaluating portfolio balance, budget, and funding risks, etc.

Step 11 – Peer Review: This step occurred after the scoring workshop and involves external validation of the process and results by independent reviewers. For this pilot project, this review involved both informal and formal review and comment by senior EM field management.

Step 12 – Final Report: The final report includes all of the information collected during the first 11 steps, including the process, the data, and the conclusions. The end result of the process is to establish a framework for prioritization of tasks in out years by updating the model created.

Integration of Prioritization and Program Planning within the Office of Waste Processing

For Waste Processing, steps four through six of the D_2O process were performed by each of three teams working in the Roadmap initiative areas of storage (WBS 1.1), retrieval, and closure (WBS 1.2 and 1.3) and pretreatment and stabilization (WBS 1.4 and 1.5).

The Office of Waste Processing strategic initiatives were further developed by the teams into a work breakdown structure (WBS) with further delineation in the form of WBS elements. After establishing the elements, each team reviewed ongoing work in these areas to ascertain how well the ongoing work addressed the problem/need.

The data packages for use in the D_2O prioritization process were developed using: the initial listing of priorities coming from the sites which had been presented in the October 2006 Technical Integration workshop, existing Technology Development and Deployment sheets from Hanford, Savannah River, Oak Ridge and Idaho, and discussions with site personnel. These reviews culminated in the identification of technology gaps. Proposed technology tasks were defined to address the technology gap; these tasks were targeted on needs which had hitherto not been addressed and which could then be added into the process and prioritized with other proposed tasks.

One output from the D_2O process is a series of plots of data points on a two-dimensional 'cost verses benefit' graph representing all possible combinations of evaluated tasks. From this plot, it is possible to identify which projects constitute the 'optimum, best value' program for a given funding level. In addition, the plot enables 'what if' scenarios to be conducted to account for an increase or a decrease in budget, directives that certain projects 'must' be done and/or changes of other variables.

The Role of Expert Judgment in Prioritizing the Office of Waste Processing Portfolio

The D_2O prioritization process provides powerful insight into maximizing the overall return on investment of the Office of Waste Processing funds. However, key to that effectiveness is the application of expert judgment to ensure the data entered into the process has the necessary quality to produce a defensible product. Furthermore, once the prioritized list is generated, expert judgment is applied to review the list and ensure it accurately reflects the EM mission. The following paragraphs capture some insights gained from the first application of the process to the Office of Waste Processing budget prioritization and how active participation by subject matter experts ensured the best possible result.

Return on Investment vs. Cost Savings: Some program investments may not yield short-term economic returns but will reduce the overall risk of successful operations in the long term. For example, the operational benefits to optimizing tank space utilization, improving measurement accuracy for particular radioactive or chemical species, or reducing the potential for melter failure have real value in surety of operations, but are difficult to quantify in financial terms, and even more challenging to quantify consistently across all areas of EM. For this reason, the process incorporates a Return on Investment approach that captures benefits to the program beyond pure cost savings. Quantification of such benefits requires a robust process for assigning quantitative values to qualitative assessments, extensive use of expert judgment, and vigorous dialogue among subject matter experts.

Common Understanding: Consistency of approach between the subject matter experts when generating input data is essential to obtaining a reliable prioritized task list. As an example, a task with the goal of shortening a facility's mission life will, if successful, reduce the time period that workers are exposed to industrial, chemical, and radiological hazards. It will also reduce the overall emissions to the environment and public. Evaluation of environmental, safety and health benefits of projects; however, may be viewed differently by different experts. If operation within the design constraints of DOE standards is deemed as fully protective of workers and the environment, then reduced mission life may be judged as having insignificant benefits to environmental, safety and health. The potential for these types of inconsistencies was evaluated during the "Output Review" step of the process and factored into the overall prioritization through refinement of the criteria and development of a common understanding of the scoring methodology applied.

Mission Differences: The mission and vision of the Office of Waste Processing differ from other EM offices. That is, some projects may be valuable to the overall EM mission, but outside the scope of the Office of Waste Processing. Once this difference was recognized by the Initiative Development Team's, the priority of such tasks was diminished for Office of Waste Processing support. This was also evaluated during the "Output Review" step of the process.

Appendix C

Waste Processing Tasks

Title	**Scope**	**WBS#**
Remote Sensor Technologies	Current waste characterization technologies require either in-tank probes or sample collection followed by laboratory analysis. A Request For Proposal will be issues to develop non-invasive tank characterization techniques that avoid the cost, personnel radiation exposure, and secondary waste generated by the existing technologies.	1.1.1.1
Solid-Liquid Interface Monitor Cold Demonstration	The safety basis for Hanford double-shell tanks limits the volume of sludge that can be stored do to flammable gas retention concerns. Current measurement technologies do not provide accurate measurements. Non-radioactive testing will be conducted on a Solid-Liquid Interface monitor to validate its ability to provide accurate volume data that meets the safety basis limit while maximizing tank utilization.	1.1.1.2
Understand the Turbidity Across a Large Uneven Sludge Surface	Assumptions of sludge settling times delay recovery of clarified supernatant. Better technologies are needed to measure the turbidity of high-level waste in-situ to optimize operations. An in-situ probe will be developed and laboratory studies will be conducted to measure turbidity in real-time.	1.1.1.3
Emergency Tank Space	Both Savannah River and Hanford are required to maintain empty double-shell tanks tank space in the event of an emergency such as a major tank leak: 1.2 million gallons at Hanford and 2 million gallons at Savannah River. If other options for emergency tank space could be developed, this would significantly reduce the need for additional tank construction. Under this task, a request for proposal would be developed to design, fabricate, and qualify a new technology to enable utilization of single-shell tanks for emergency tanks space.	1.1.1.4
Numerical Models for Gas Retention and Release	Models of gas retention used in the tank farm safety basis result in conservative restrictions on the volume of sludge that can be stored in tanks. A review of historic data will be conducted along with lab studies to develop and validate new gas retention models that reduce conservatism and enable fuller tank utilization.	1.1.1.5
Void Fraction Meter	The current safety basis for Hanford tanks requires an estimate of gas retention in the high-level waste sludge. The current estimate is seen as conservative, and this conservatism could be reduced if a method existed to measure the actual gas retention in the sludge layer. A request for proposal will be issued to design, fabricate, and cold test a technology for in-situ measurement of gas retained in tank sludges.	1.1.1.6

Title	**Scope**	**WBS#**
Carbonate/Aluminate Corrosion Studies to Support Double-Shell Tank Life Extension	The most critical variable determining corrosion of tanks is the pH which is buffered principally by carbonate and aluminum species. A mechanistic, surface chemistry understanding will be developed based on important solid phase transformation reactions as well as kinetic and thermodynamic data	1.1.2.2
Improving Waste Tank Integrity	Incomplete understanding of corrosion mechanisms has resulted in a "one size fits all" conservative corrosion control standard. Experimental studies will be conducted to derive a more complete understating of corrosion mechanisms to enable informed corrosion control requirements and establish risk based methodologies.	1.1.2.3
Structural Integrity Analysis of Double-Shell Tanks	The safety basis for most tanks use the original design limits based on assumed storage conditions that do not typically represent real conditions. This has resulted in conservative utilization. This task will conduct analyses to rigorously demonstrate structural integrity of Hanford tanks to support storage of larger waste volumes and higher density slurries.	1.1.2.4
Structural Integrity Analysis of Single-Shell Tanks	DOE single-shelled tanks are generally beyond their original design life, and due to the extension of waste treatment schedules, will need to continue to function safely for several more decades. This task will conduct analyses to rigorously demonstrate structural integrity of Hanford single-shell tanks and ancillary equipment to ensure their acceptable performance over this extended timeframe which includes not only normal operating loads but also loading induced by upcoming retrieval operations	1.1.2.6
Tank Non-Destructive Examination	Assessing the structural integrity of double-shelled waste tanks is critical to ensure their performance throughout the cleanup mission. Current Non-Destructive Examination technologies are slow, expensive and do not provide a complete data set. A request for proposal will be issued to develop new Non-Destructive Examination techniques for measuring tank integrity with the goal of reduced cost and providing a more thorough analysis of tank structures and ancillary equipment.	1.1.2.9
Electrochemical Noise Probe Optimization	Advanced real-time probes are needed to assess the corrosion potential of waste to protect tanks and associated infrastructure. The electrochemical noise probes are useful tools, but have not reached their full potential. This project will develop new sensors for the electrochemical noise probes and develop more automated data analysis techniques to support use in decisions for tank farm operations.	1.1.2.11

Title	Scope	WBS#
High-Level Waste Tank Structural Integrity Assessment	Waste storage limits are currently defined by simple limit-load analysis that do not account for flaw stability for cracked tank conditions. Using Failure Assessment Diagrams and/or J-T Integral analyses, flaw stability methodologies will be developed to predict structural soundness of cracked tanks enabling maximum safe fill level.	1.1.2.12
Tank Repair	While tank integrity programs are in place for DOE's double shelled tanks, methods to repair tanks if a leak should occur do not exist. Industry has developed some measures of repairing leaky tanks; methods such as patches, plugs and the use of polymers are in use on a variety of drums and tanks. Under this task, a request for proposal would be developed to design and test technologies to repair leaks in tanks so they can return to service.	1.1.2.13
Vapor Space Corrosion and Liquid/Air Interface Corrosion	The mechanisms for corrosion in tank vapor space and air interface are not well understood and lead to unknown risks. Methodologies will be developed to predict and subsequently provide controls to preclude corrosion in the vapor space/interface.	1.1.2.14
Raising the Lower Flammability Limit for Hydrogen from 4 to 5 percent	Tank farm operating procedures limit activities to those that will not exceed 25 percent of the lower flammability limit for hydrogen. The Nuclear Regulatory Commission uses a lower flammability limit of 5, while DOE uses 4 percent putting a 25 percent higher constraint on DOE operations. A review will be conducted of the Nuclear Regulatory Commission basis for changing the acceptable lower flammability limit levels from 4 to 5 percent and implement for DOE.	1.1.3.1
Gas Generation Models for Hanford and the Savannah River Site	Calculations of flammable gas generation are critical to safe storage and treatment of high-level waste. The use of separate models at Hanford and Savannah River for similar waste types is troublesome to regulators. Experts involved in each model will work together to develop a single integrated and defensible model applicable to both sites.	1.1.3.2
Effects of Facility Operations on Tank Vapor Production and Release	Poor understanding of tank vapor generation and the need to safeguard worker health resulted in significant delays and expense for DOE while work was stopped to study and mitigate the hazard. Proposed treatment operations will affect material that both remains in the tanks and recycles back to the tanks. The resulting tank waste will likely have a different vapor generation rate and speciation. This task will study and quantify the effects of proposed operations on tank vapor production and release to mitigate personnel exposure and delays.	1.1.3.3

Title	Scope	WBS#
In-Situ Hydroxide, Nitrate, and Nitrite Probe	Tank corrosion standards and waste feed acceptance requires detailed composition information that is currently only available by time consuming sampling followed by laboratory analysis. In this task, reduced schedule and reduced worker dose will be achieved by development of a Raman based probe for in-tank quantification of hydroxide, nitrite, and nitrate. This probe will use the same technology in the Raman skid developed for the S-109 Bulk Vitrification Demonstration Project.	1.1.3.4
In-Situ Sludge Mass Acoustic Meter	Knowledge of sludge density is critical to flowsheet calculations related to batching and prediction of waste throughput. Using a new ultrasonic technique, a sludge density probe will be developed for use in high-level waste tanks and process lines.	1.1.3.6
Improved Understanding of Tank Waste Chemistry	New methods of obtaining rapid, high quality tank farm characterization data need to be adopted by DOE laboratories and waste processing plants. Some new techniques have been developed; however, for routine use with tank farm samples, they are unproven. This task will perform and in-depth evaluation of methods across DOE and develop a request for proposal for external methods. Techniques that show a high promise to fill existing gaps will be further developed to maturity.	1.1.3.8
Samplers to Improve the Representativeness of the Samples	Waste treatment requires detail chemical and isotopic characterization. However, waste characterization is complicated by stratification and a limited number of access points (risers). This task will develop a handbook on previous sampling systems used in underground storage tanks and develop a multi-dimensional sampling tool allowing for multiple sampling during single tank entry.	1.1.3.9
Thermodynamics/Kinetics Study of Solids and their Dissolution	At the Savannah River Site, the sludge remediation plans include the use of caustic leaching to reduce the volume of sludge, which must be vitrified. Laboratory testing conducted thus far is not sufficient for determining process conditions at full scale. This task will perform caustic leaching studies on Savannah River sludge to support flowsheet development and scaling.	1.1.3.10
Film and Plug Removal	Plugged transfer lines significantly impact tank farm and waste treatment operations. This project will develop and test simple methodologies to remove plugs in pipelines. Initial work will include seeking commercially available technology through a Request for Proposal.	1.1.3.12

Title	Scope	WBS#
Recycle from New At-Tank processing on Tank Farm Operations	Several alternative at-tank or near-tank pretreatment processes have been proposed for DOE tank waste to accelerate or enhance the current baseline operations. It is likely that any recycles from these proposed processes would need to be discharged to the tanks. This task will analyze the process flowsheets and assess the impact of these operations and recycles on tank integrity (including corrosion), tank farm operation, and eventual waste recovery and treatment.	1.1.3.13
Rheological Modifiers and Wetting Agents	To increase processing rates and decrease melt times, DOE waste treatment plants plan to remove significant fractions of water from their high-level waste slurries prior to vitrification. However, at these high solids loadings the rheological properties including yield stress and viscosity make mixing, transporting, and processing these materials difficult. This task will test select additives that can be mixed with waste to reduce the rheological properties to enable processing at these higher solids loadings.	1.1.3.14
Actinide Solubility in Highly Alkaline Wastes	Actinides solubility defines how waste will be stored and processed, but the predictive capability is not sufficient to use in nuclear safety calculations. Detailed models will be developed to predict actinide solubility sufficient for use in calculations.	1.1.3.15
Retrieval Requirements/ Knowledge Center	Technologies for retrieval, cleaning, sampling, etc., have been deployed on a tank by tank basis across the complex with very little synergy and sharing of detailed information to assist with future development activities. A team approach utilizing commercial components in an integrated system is needed to efficiently and effectively deploy technologies for waste retrieval. A team of technical experts will collect and manage a database for waste retrieval technologies and lessons learned and utilize it to develop requirements and future technology gaps.	1.2.1.1
Bulk Waste Retrieval Improvements	Current practices to mobilize and transfer bulk wastes from high-level waste tanks have been successful but costly and often leave residual materials in the tank. Existing baselines are based on cantilever slurry pumps which are expensive and have design issues that limit their operating life. This study will be begin with current practice submersible mixer pumps and consider failure modes, design weaknesses, and cost efficiency issues. Alternative and/or incremental improved pumping technologies will be developed. The viability will be demonstrated in a cold test.	1.2.1.2

Title	**Scope**	**WBS#**
Heel Retrieval Technologies for Tanks with Significant Obstructions	No consistent proven technology exists for heel removal from high-level waste tanks with significant obstructions such as pipes, cooling coils, support columns, and instrumentation probes. Technologies deployed have been on a tank-by-tank basis, are inefficient, and quickly yield diminishing returns. Integrated systems, utilizing prior experience and commercial technology, to remove residual heel material in tanks with significant obstructions will be designed, developed, and tested. Results from the retrieval knowledge center will be utilized to initiate this effort.	1.2.1.3
Heel Retrieval for Large Cobble, Rubble, and Sand	Typical waste removal methods preferentially leave larger sized waste material, in the forms of cobbles, rubble, and sand (i.e., materials like zeolite) at the bottom of the tank along with other stubborn waste heel material. It takes significant operation and equipment time to size reduce these larger "chunks" of waste. Integrated systems and strategies, utilizing prior experience and commercial technology, to break up and remove residual heel material that consists of large cobble, rubble, and sand will be designed, developed, and tested. Results from the retrieval knowledge center will be utilized to initiate this effort.	1.2.1.4
Size Optimization Studies and Technologies	Current practices to retrieve residual wastes have often led to the need to consider altering the size of the remaining material. Size reduction, nor the impacts on downstream processes is not always thoroughly considered or understood. This could result in higher than necessary liquid addition to tanks and unintended design or process changes downstream. This effort will study size optimization parameters and waste chemistry and address particle size impacts on transfer requirements, receipt tank operations, and downstream processes. This study will lead into the identification of technologies for addressing particle size requirements.	1.2.1.5
Dry Retrieval Technologies	In many high-level waste tanks, it is necessary to manage the liquid levels below previous leak sites. This will require so-called dry retrieval methods to remove the waste from those tanks. This effort will develop, prototype and cold test dry retrieval technologies that permit collection of residual waste from tanks that leak – to eliminate the use of large liquid volumes. Results from the retrieval knowledge center will be utilized to initiate this effort.	1.2.1.6
Annulus Retrieval Technologies	Technologies deployed for tank primary cleaning are not easily adaptable for annulus deployment due to the smaller size and confines of the annulus. Integrated systems and strategies, utilizing prior experience and commercial technology, to inspect and remove waste from an annulus will be designed, developed, and tested. Results from the retrieval knowledge center will be utilized to initiate this effort.	1.2.1.7

Title	**Scope**	**WBS#**
Idaho Calcine Retrieval	The highly radioactive calcine material at Idaho must be removed from difficult to access storage bins and disposed of to an acceptable storage location. A concept for this removal has been developed. Additional concepts will be evaluated and the engineering development completed. A pilot scale testing will be performed and a recommendation for deployment made.	1.2.1.8
Reliable Exhausters	At Hanford, portable and highly reliable exhausters are needed for single-shell tank retrieval operations. Current commercial exhausters have had reliability problems leading to significant downtime and maintenance. The requirements for the exhauster will be reviewed and revised. A request for proposal will be developed and issued and collaboration with industry will be initiated.	1.2.1.9
Cross Site Transfer Mechanisms	As retrieval operations have increased over the last several years, the transfer of waste from a tank being retrieved to a receipt tank has also increased in frequency. This leads to an increased concern for the potential plugging of lines. A better understanding of the physical and chemical conditions of the waste that allow a blockage to occur may allow blockages to be prevented from occurring. Mechanisms that contribute to pipeline blocking will be investigated. Waste transfer strategies that will prevent blockages will be developed as knowledge is gained.	1.2.1.10
Aerosolization Understanding and Characterization	Conservative assumptions are made with regards to aerosolization within high-level waste tanks. These assumptions drive facility implementation of retrieval technology due to safety basis or other requirements. This may prevent the most efficient method from being deployed. An industry search will be performed to determine if there is any technology suitable for characterization of aerosols in order to obtain actual tank data. Depending on the results of this effort, systems will be tested and compared to assumptions and recommendations provided. Longer term efforts may address the reduction of aerosols by eliminating vortexing, etc., by the waste retrieval technology selection.	1.2.1.11
Sampling/Characterization after Bulk Retrieval	Characterization of high-level waste tanks after bulk retrieval is critical to selecting the most efficient tank retrieval/cleaning methods. Remote tooling concepts and strategies are currently deployed as tank and waste specific. Adaptable (or universal) use of remote tool components and technologies that are not required to be tank/waste specific (i.e., masts, drive components, vision systems, end effectors, etc.) does not currently exist, often resulting in expensive and time-consuming development. Adaptable or universal remote sampling and characterization tools, concepts, and strategies for deployment in high-level waste tanks and ancillary systems after bulk retrieval will be developed Industry and prior experience will be utilized.	1.2.1.12

Title	Scope	WBS#
In-situ Characterization for Retrieval	The current method at Savannah River for processing tank materials is to pull samples and have them analyzed for physical and chemical properties. Based on the physical properties the contents of the tank are adjusted or left as is. If the contents are further concentrated, such as to optimize pumping system capabilities, additional samples are required to verify the changes made do not impact the pumping system. The pulling and analyzing of additional samples becomes costly. This effort will develop and test in-situ rheology measurement technologies for multiple layers so that mixing and pumping qualities are maintained without having to stop and pull samples.	1.2.1.14
Requirements Definition for Post Cleaning Tank Integrity	Following tank cleaning high-level waste tanks will be closed by filling with a grout material. Specific requirements on maintaining tank integrity during operation are defined and in use. Requirements for tank integrity during and following tank cleaning have not been defined. This task will develop a requirements definition for tank integrity after cleaning to allow for closure focusing on structural integrity modeling and tank corrosion requirements.	1.2.2.1
Dissolution Mechanisms with Varying Cleaning Agents	Final cleaning of tanks typically involves use of an acid to aid in dissolving the residual waste. Information is needed on speciation of the material in the tanks, as well as the dissolution mechanisms, so that the chemical cleaning steps can be tailored to minimize quantities of reagents and reduced contact durations. A study will be designed and executed to collect data and create predictive cleaning models that will allow optimization of the reagent selection, volume of reagent and contact duration.	1.2.2.2
Enhanced Chemical Cleaning	The baseline process for chemical cleaning of the residues in high-level waste tanks generates an enormous amount of marginally soluble sodium oxalate, which must be disposed. A method is needed for destroying or minimizing impact of oxalate, or identifying alternative reagents that would also be compatible with downstream storage and processing. Research is needed to identify alternative technologies or approaches, including vendor capabilities, to identify a viable solution that can be selected for deployment. This study will develop and demonstrate effective methods to reduce or eliminate oxalate use during chemical cleaning of tanks.	1.2.2.3
Evaluation of Complex Wide Chemical Cleaning Strategies	The use of chemical cleaning in combination with mechanical cleaning has become a necessity within the DOE complex particularly at the Savannah River site. A link between the two efforts and a complete understanding of the impacts of chemicals (including the use of water) on various waste types (salt, sludge, etc.) is needed. A team of technical experts will collect information, data, and lessons learned from chemical cleaning studies and deployments and provide recommendations for future studies. The need for a flowsheet model may be warranted as well.	1.2.2.4

Title	Scope	WBS#
Integration of Decontamination and Cleanout Technologies	There is a need for the integration of tank decontamination and cleanout technologies with treatment of solutions downstream. Minimizing this waste, by simple treatment (neutralization or volume reduction) is far better than delivering millions of gallons of extra solution to the final process (e.g., vitrification), which may not even be capable of handling those wastes. This activity will investigate treatment methods (including obtaining information from industry) and recommend one that can be effectively applied under the requirements of the tank farm system. Assuming that there were promising approaches, a development or demonstration project may be pursued.	1.2.2.5
Gas Generation Rates and Speciation During Chemical Cleaning	The baseline process for chemical cleaning of the residues in high-level waste tanks involves use of oxalic acid. In contact with carbon steel, the acid generates hydrogen gas during corrosion. The rate of hydrogen production is key to safe processing and control strategies. A designed study will be performed to obtain a mechanistic understanding of gas generation rates and speciation during chemical cleaning that can be utilized across the high-level waste system to potentially aid in planning for chemical cleaning.	1.2.2.7
Leaching of Radionuclides from Tank Fill for Closure	The leaching of long-lived radionuclides (such as Tc-99, Se-79, and I-129) is a primary influence on the Performance Assessment calculations for shallow land burial of low-level waste. Limited data is currently available for grout utilized for tank closure. Extreme bounding values from literature are often used to support the Performance Assessment. A systematic study will be performed to collect data and place in database for Complex-wide use.	1.3.1.1
Permeability Measurements in Cementitious Fill Mixes	The permeability (hydraulic conductivity) of grouts used for tank closure (and low-level waste immobilization) is an important input parameter for Performance Assessments. This task will evaluate techniques developed for permeability measurements. One technique has been demonstrated to measure grout permeability reproducibly and accurately within several hours. Currently, hydraulic conductivity is reported as a single value and the variation of the conductivity has not been assessed.	1.3.1.2
After-Cleaning Residual Waste Characterization Methods	In-tank characterization of residual waste from both a volume and chemical/radionuclide content is difficult and subjective. More accurate and less time consuming methods are needed to provide this characterization information in order to support tank closure efforts. An evaluation of existing tools for residual waste characterization will be performed. Promising methods will be selected for further development and testing. A test program will be conducted taking into account tank closure needs and requirements.	1.3.1.3

Title	Scope	WBS#
Improved Sampling Concepts for Tank Closure	Sampling residual material after retrieval/cleaning efforts are completed and prior to closure will be difficult. This sampling effort may involve films on surfaces or very small amounts of material behind a large amount of obstructions (e.g., cooling coils). Industry and prior experience will be utilized to develop and test methods for sampling these small amounts of materials. Statistical studies will also be performed to assist in guidance as to where and how many samples should be collected for tank closure.	1.3.1.4
Fixative for Contaminated Pump Pits	During waste processing campaigns, waste retrieval and closure the pump pits and other ancillary facilities become contaminated with high airborne contaminants and often work must be stopped until decontamination has been completed. Methods will be developed and tested to reduce airborne contamination in work areas, such as pump pits. Methods of fixing the contamination using fogging techniques may fill this need.	1.3.1.5
Key Variables that Influence Performance of Tank Closure Grout	Operational and salt solution compositional variations impact the processing and performance properties of tank closure grout. Models will be developed for the relationship between operational and compositional variables and processing/performance properties using a statistically designed experimental approach. To understand/quantify the key variables that affect the grout properties and to be able to adapt to either intended or unintended changes in the plant operations or waste stream by recommending changes to the grout formulation.	1.3.1.6
Transport of Grout into Coils, Transfer Lines	Closure of high-level waste systems is in the very early stage of development. Little effort has been placed on defining the materials or methods for immobilizing the contents in intra/inter area transfer lines, cooling coils, annulus, etc. The selected material(s) must satisfy closure requirements and be flowable to fill the necessary volumes. A study will be designed and performed to evaluate improved materials for closing ancillary systems and commercially available equipment will be evaluated for its applicability to this effort.	1.3.2.1
Residual Waste Characterization Methods for Ancillary Systems	Closure of high-level waste systems is in the very early stage of development. Little effort has been placed on defining the materials or methods for immobilizing the contents in intra/inter area transfer lines, cooling coils, annulus, etc. The selected material(s) must satisfy closure requirements and be flowable to fill the necessary volumes. A study will be designed and performed to evaluate improved materials for closing ancillary systems and commercially available equipment will be evaluated for its applicability to this effort.	1.3.2.2

Title	Scope	WBS#
Strategy for Handling of Closure of Ancillary Systems Flushing and Grouting Compatibility, etc.	In-tank characterization of residual waste both from a volume and chemical/radionuclide content is difficult and subjective. This will become even more of a challenge as ancillary systems are closed. Determining the amount and content of waste that is trapped inside pump, coils, and lines will be extremely challenging. An effort will be initiated to develop a set of tools and methods for characterizing the amount of residual waste inside pumps, coils, and transfer lines. Industry and complex wide experiences to date will be utilized.	1.3.2.4
Quantity/ Velocity of Flush Water	The overall effort for closing ancillary systems is very large and has not yet been address in a systematic manner. A complex wide expert panel will be assembled to develop strategies for closure of ancillary systems including flushing, grouting, and compatibility issues. This effort will then be utilized to further define technology gaps.	1.3.2.5
Pilot Scale Demo System	The complex is in the early stages of final cleaning, closure, and capping and key decisions will be made over the next several years. Down select of technologies will be made and complex wide pilot scale demonstration system(s) for the many aspects of tank closure could be critical to that selection process. Such a system could provide critical data and help define requirements for long-term performance and monitoring. Many unknowns exist for what the requirements for this system should be, thus, the first year of this effort needs to be focused on developing specifications. A multi-disciplined team from across the complex will collect the needs for such a system and define the specification prior to soliciting proposals.	1.3.3.1
On-line Alpha and Strontium Monitor	Processing of waste through the Savannah River Site Salt Waste Processing Facility and the Actinide Removal Process is dependent on sample results from the alpha/strontium removal step. An on-line monitor would reduce cycle time. This project will develop and test potential monitors.	1.4.1.1.1
Development of Rotary Microfilter for Savannah River Site/Hanford Deployment	At-tank processing will require solid/liquid separation technology. The rotary microfilter is a very promising technology. This project will complete design and construction of rotary microfiltration system for applications at Savannah River and Hanford.	1.4.1.2.1
Alternative Media for Cross Flow Filtration	Solid/liquid separations within the Hanford Waste Treatment Plant are to be performed using cross flow filtration. Filtration is one of the rate-limiting process steps. This project will examine methods to improve filtration flux.	1.4.1.2.2
In-Riser Cesium Ion Exchange System	To expedite processing of Savannah River Site high-level waste before the startup of the Savannah River Site Salt Waste Processing Facility, an in-riser ion exchange system is being designed and tested. This project will complete design of the in-riser Cesium Ion Exchange System process and deliver equipment for installation.	1.4.1.3.1

Title	Scope	WBS#
Fractional Crystallization	Fractional Crystallization is being examined as a supplemental pretreatment alternative. Bench scale testing has shown Fractional Crystallization to provide sufficient cesium decontamination. This project continues the development and will complete pilot scale demonstration of fractional crystallization for cesium removal.	1.4.1.3.2
Improved Strontium and Actinide Separations	The throughput associated with alpha and strontium removal at Savannah River is dependent on the removal kinetics. This project continues work on improving the sorbent technology and will develop of advanced sorbents for replacement/supplement of monosodium titanate. The planned work includes simulant and actual waste testing to demonstrate performance of revised sorbents.	1.4.1.3.3
Technetium Ion Exchange	Technetium is currently not required to be removed from high-level waste at Hanford or Savannah River prior to immobilization. However, it is possible that Tc removal may become a requirement at some point in time. This project would develop an at-tank treatment option if needed.	1.4.1.3.4
Second Generation Caustic Side Solvent Extraction Solvent	Improvements have the potential to decrease the life cycle cost of the Salt Waste Processing Facility by reducing solvent costs.	1.4.1.3.5
Caustic Side Solvent Extraction Process Enhancements	Operation of centrifugal contactors in the Caustic Side Solvent Extraction process at Savannah River due to solvent carryover. This project will optimize centrifugal contactor design/performance for Salt Waste Processing Facility to avoid solvent carryover.	1.4.1.3.6
In-tank Strontium/Transuranic Removal for Hanford Tanks	Two Hanford tanks require Strontium/transuranic pretreatment. Currently, the Strontium/transuranic removal is expected to be performed in the Hanford Waste Treatment Plant. It is possible to perform this operation in the Hanford tank farm, which will represent an easier and cheaper solution. This project will complete flowsheet development for that capability.	1.4.1.3.7
Disposition of Defense Waste Processing Facility Recycle after Salt Waste Processing Facility Startup	The largest influent to the Savannah River Site tank farm is recycled water from the Defense Waste Processing Facility. Following startup of the Salt Waste Processing Facility, the Defense Waste Processing Facility recycle will increase greatly and will contain enriched uranium that presents a problem in the Savannah River Site tank farm. This project will develop strategies for dealing with the enriched uranium.	1.4.1.5.1

Title	Scope	WBS#
Secondary Waste Treatment/Immobilization for Hanford Waste Treatment Plant	Secondary waste will be generated from the operation of the Hanford Waste Treatment Plant. This waste will be returned to the tank farm. A flowsheet for treating this stream does not exist. Devise treatment flowsheet for secondary wastes and demonstrate with testing on simulants and actual waste samples.	1.4.1.5.2
Tank 48 Treatment Options	Tank 48 at Savannah River contains an organic-laden waste that does not have a defined treatment path. Steam reforming is being pursued as a primary option. This project will develop the backup technology and perform pilot scale testing and actual waste testing for Wet Air Oxidation treatment of tetraphenylborate containing waste in Tank 48 at the Savannah River Site.	1.4.1.6.1
Non-Destructive Assay/Non-Destructive Examination Technology for Transuranic Wastes with High Neutron Activity	Californium waste is currently held in inventory because of the difficulty in characterizing the transuranic content in high neutron fields. This project will examine neutron methods to discriminate U-234 from other neutron emitting isotopes in transuranic waste, which will allow the waste to be characterized and shipped to the Waste Isolation Pilot Plant.	1.4.1.6.3
Understanding Sludge Chemistry to Improve Agglomeration	Current Savannah River sludge processing is experiencing poor sludge settling leading to a less dense settled sludge phase, which increases cycle time within the Defense Waste Processing Facility when processed. This project will identify potential additives to densify sludge and test the additive with simulants and down select. This will be followed with a test with actual waste.	1.4.1.7.1
Thermodynamic data and computational methods for liquid waste flowsheet modeling	Thermodynamic data exists for many but not all key species that exist in alkaline waste throughout the complex. Improved studies can lead to the development of improved waste processing flowsheets. This project will continue to generate solubility data.	1.4.1.8.1
Advanced Mixing Models	To accomplish mixing in large tanks, plant operations typically run mixing pumps for extended durations which limits pump life and extends schedule durations. This project will use computational fluid dynamics to develop models for large tanks to determine mixing time required to achieve homogeneity would increase pump life and short process times.	1.4.1.9.1
Integrated System Model	Current capabilities to model the flowsheets of individual process facilities are less than adequate to support integrated flowsheets. This project will improve commercial codes to develop integrated models.	1.4.1.10.1

Title	Scope	WBS#
Caustic Recycle from Waste Treatment and Disposal Operations	Removing aluminum from sludge introduces significant quantities of caustic, which increase the sodium load to Savannah River and Hanford vitrification processes. This project examines possible caustic recycling flowsheets. The project will complete design of pilot scale module for electrochemical caustic recovery process - in parallel; a down select will be performed of the existing tasks.	1.4.2.1.1
Aluminum Leachate Stability	The removal of aluminum from sludge to allow for higher waste loading is dependent upon the stability of the aluminum leachate. This project will determine the stability of supersaturated aluminum-rich streams - then determine the impact on downstream processes.	1.4.2.1.2
Sludge Mass Reduction	Increases in the amount of sludge mass stored at Savannah River could increase the total amount of mass that must be processed through the Defense Waste Processing Facility, increasing the cost and duration of high-level waste processing. This project will perform actual waste tests to demonstrate the sludge mass reduction process. Also provide revised glass model for leached sludge.	1.4.2.1.4
Develop Technology for Removal of Higher Fractions of Boehmite	The Waste Treatment Plant aluminum leaching flowsheet will not remove sufficient quantities of aluminum due to the slow dissolution kinetics of boehmite (an aluminum salt in high-level waste). Improvements to the flowsheet are needed to reduce the impact of higher amounts of boehmite. This project will survey and test potential solutions for increased removal of boehmite: a) reaction accelerants; b) feed segregation (segregation of high boehmite feeds); and c) alternative leach conditions (temperature, hydroxide).	1.4.2.1.5
Improved Oxidative Leaching	Current flowsheets that have been studied for removing chromium from Hanford high-level waste sludge do not remove sufficient amounts to allow optimum high-level waste vitrification performance. This project will study different oxidative leaching flowsheet improvements to address this issue.	1.4.2.2.1
Effect of Oxidative Leaching on Behavior of Actinides	A significant fraction of the sludge batches at Hanford are limited by the chromium content and require chromium removal. Preliminary studies indicate the Cr removal flowsheet will impact the chemistry of the actinides. Understanding the downstream ramifications is important to ensure criticality safety. This project will survey of three potential solutions a) alternate oxidants; b) post leach reductants ; and c) sequestering agents. Test top candidates with simulants. Test final candidate with actual waste.	1.4.2.3.1

Title	**Scope**	**WBS#**
Hanford High-Level Waste Melter Bubbler and Film Cooler Development	Current Hanford high-level waste melters are rated at 3MT glass/day. To accelerate the Hanford tank cleanup, a faster high-level waste vitrification rate is desired. The bubbler system is not yet optimized and its optimization depends heavily on the frequency of film cooler plugging and ability to clear plugs while running. It has been estimated that optimizing the bubbler configuration may increase melting rate to as high as 4MT/day. This task will evaluate and test bubbler designs aimed at achieving the 4MT/day rate and the required film cooler/cleaner system to allow efficient operation.	1.5.1.1.1
Demonstrate Advanced Hanford High-Level Waste Melters	Several activities within WBS 1.5.1 and WBS 1.5.2 are developing modified technologies for high-level waste melting and glass formulation. To implement these technology improvements, a pilot melter must be designed, constructed, and tested. This task will design, construct, and test a pilot scaled melter system that incorporates the advancements developed in other WBS 1.5.1 and 1.5.2 tasks. This testing will significantly reduce the technical risks associated with implementing new technologies into highly radioactive waste treatment plants and will generate data necessary for final design and compliance of the new melter systems.	1.5.1.1.6
$Ce(NO_3)_4$ Can Decon	The rate of Hanford high-level waste canister decontamination limits time required to process each can to roughly 19 hours. The canister decontamination system must operate faster if melter production rate is to be increased. There is evidence that the use of higher concentrations of $Ce(NO_3)_4$ and/or higher temperatures could result in a decontamination time of roughly half the current time. This task will evaluate the options for increasing decontamination rate and will perform decontamination testing to support a flowsheet change.	1.5.1.1.7
Waste Treatment Plant Low-Activity Waste Utilization Engineering Study	The current Waste Treatment Plant design includes an empty process cell (i.e., the third melter cell). With the design and construction nearing completion and sodium amounts for leaching increasing, it is critical to evaluate the potential options for using the third cell to improve the treatment rate of high sodium salts at Hanford. This task will evaluate options and make recommendations for the used of the third melter cell in the Hanford Low-Activity Waste vitrification facility.	1.5.1.2.4
Forced Convection System in Existing Defense Waste Processing Facility Melter	The rate of glass melting in the Defense Waste Processing Facility is limited by heat transfer from the melt to the feed (or cold-cap). A glass pump that is currently being used to increase heat transfer has a limited effect. This task will evaluate and demonstrate alternative methods to increase heat transfer rate within the Defense Waste Processing Facility melter. If employed, the Defense Waste Processing Facility melter production rate may be increased by roughly 30 percent.	1.5.1.3.1

Title	Scope	WBS#
Alternative Heating Methods (Microwave and Terahertz [THz])	The rate of high-level waste melting is generally limited by the ability to supply energy to the cold-cap. Heat transfer can be improved by agitation, but there is a limit to this increase because of film cooler plugging, channeling, and limited area of impact. Additional power input could drive off the excessive water being fed to the melters to increase production rate. Both microwave and Terahertz assisted heating will be evaluated as potential technologies to improve melt rate for current joule-heated melters. The units will be tested at bench scale and demonstrated in scaled melter tests. Implementation of such a system will reduce the sensitivity to feed water content and significantly increase melter throughput.	1.5.1.3.2
Dome Header Cleaning	The Defense Waste Processing Facility melter data indicates that the total power to the dome heaters has decreased by ~20kW over the life of the melter. This decreases the overall energy to the system, limiting production capability. To minimize the risk of failing a dome heater due to deformation, their operation temperatures are maintained at 965° Celsius. This temperature limit reduces the ability to supply heat to the melter. This task will evaluate, test, and perform preliminary design of methods to increase the effectiveness of dome heaters in the Defense Waste Processing Facility. The activities include the development of heater washing system and a heater support. If successfully implemented, the advanced heater system will increase the glass production rate by over five percent.	1.5.1.3.3
Development of Millimeter Diagnostics to Support High-Level Waste/Low-Activity Waste Melter Operations	There are no reliable methods for monitoring the processes at the surface of waste glass melters. These processes are key to optimizing melting rate and avoiding salt accumulation. Millimeter-wave diagnostics has a high potential to meet these needs. This task will develop and demonstrate the mm-wave diagnostic technology for application in waste glass melting. If successful this technology facilitate 1) optimal melter operation that could increase melting rate, and 2) operating closer to salt accumulation limits that would increase loading of waste in glass.	1.5.1.3.4
Increase Melt Surface Area and/or Operating Temperature for Hanford and Defense Waste Processing Facility Joule-Heated Melters	Melter throughput is directly linked to the mission lives at Hanford and Savannah River. Two methods of increasing the waste throughput of the Defense Waste Processing Facility (high-level waste) and Hanford (high-level waste and low-activity waste) Joule-heated melters are: 1) by increasing the cross-sectional area of the melt pool, and 2) by increasing the operating temperature. This task will evaluate the ability to reduce the melter refractory and increase melter area or increase operating temperature without changing the footprint of the melters.	1.5.1.3.6

Title	Scope	WBS#
Cold Crucible Induction Melter Demonstrations	Joule-heated melters are limited in throughput for radioactive waste processing due to constraints on: 1) operating temperature due to materials of construction; 2) waste loading due to crystal; 3) viscosity; 4) electrical conductivity constraints; and 5) operating lifetime caused by corrosion of materials and crystal accumulation. Cold Crucible Induction Melter technologies are not as tightly constrained in those areas, which could yield a step function increase in waste loading and throughput. This task will demonstrate the Cold Crucible Induction Melter technology for DOE high-level waste and develop data to support a decision on if the Cold Crucible Induction Melter should be implemented in either of the United States high-level waste treatment plants.	1.5.1.4.1
Broader Hanford High-Level Waste Glass Formulations	Current formulations for Hanford high-level waste have covered only a small fraction of the anticipated wastes and are generally conservative in loading. This task will broadening the set of glass formulations to cover a broader range of the waste types at Hanford and development of less conservative waste loadings, while maintaining the current property requirements.	1.5.2.1.1
High Waste Loading Glasses for Defense Waste Processing Facility using Existing Melter Technology	Glass formulation strategies at the Defense Waste Processing Facility have made significant improvements in waste loading and melt rate over the past four – six years resulting in significant improvements in waste throughput. Although the current strategy was effective, maximum waste loadings have leveled at 35 – 38 percent. This task will focus on strategic formulation efforts that allow higher loaded glasses to be targeted without compromising melting rate or product quality. In addition, glass formulation activities will evaluate a broader composition region to account for direct disposal of secondary waste and/or troublesome components that exceed current model development ranges.	1.5.2.1.2
Develop Predictive Models for Hanford and the Defense Waste Processing Facility High Waste Loading Glasses	Current high-level waste glass property models are limited in compositions at relatively low loadings and do not cover the ranges of glasses to be processed. Alternative models will be required to optimize glass formulations for higher waste loadings and broader waste compositions. This task will develop data and property models to support increased loading of high-level waste at Hanford and Savannah River.	1.5.2.2.1

Title	Scope	WBS#
Develop Data and Models for Slow-Cooled Glass Durability	Compositional projections at Savannah River and Hanford suggest relatively high concentrations of aluminum oxide. This leads to possibility of nepheline formation on slow cooling of the glass. If nepheline forms, there is a strong possibility of a significant durability reduction. Nepheline formation has limited waste loadings for glass formulation efforts at the Defense Waste Processing Facility and Hanford. Although a nepheline discriminator does exist, glasses that "fail" this constraint but do not form nepheline have been formulated (i.e., the model is too conservative). This task will develop data and models to allow for higher loading of high alumina wastes while protecting against unsatisfactory glass durability.	1.5.2.2.3
Predictive Model for Glass Production or Melt Rate	As a result of changing the chemistry and increasing loading of high-level waste in glass, it is anticipated that melter throughput rate will be reduced. Current melting models do not accurately predict composition effects over broad composition regions nor are they quantitative. This task will develop data and models for prediction of composition effects on melting rate of high-level waste glasses. These models will be used to optimize high-level waste throughput at Hanford and Savannah River.	1.5.2.3.2
Crystal Tolerant Glass Formulations	The loading of high-level waste in glass is currently limited by liquidus temperature (T_L) or temperature at 1 percent crystal ($T_{1\ percent}$). A method of high-level waste glass formulation that allows for significant increases in waste loading while not increasing the risk of melter failure would decrease the life cycle cost. This task will develop the data and formulations necessary for adopting the new glass formulation method that allows significant crystals in current glass melters without increased risk of melter failure.	1.5.2.4.1
Advanced Melter Formulations with High Loading	Glass formulations for Joule-heated melters are limited by a number of constraints that impact loading such as operating temperature, corrosion of glass contact materials, and crystal formation. The use of an advance melter system (e.g., the cold crucible induction melter) would allow for formulations that are not as tightly constrained in those areas which could yield a step function increase in waste loading. This task will develop glass formulations suited to the advanced melter concepts being investigated so that there impacts can be demonstrated.	1.5.2.4.2
Phosphate Glass for High-Level Waste	Several components in United States high-level waste have limited solubility in borosilicate glasses (e.g., P, Cr, S, and F). These components are highly soluble in phosphate glasses. Although development work has been performed on phosphate waste glasses for 30 years, the maturity of the technology is insufficient to justify implementation and makes accurate determination of the costs and benefits difficult. This task will perform the testing necessary to demonstrate the phosphate glass potential for replacing silicate glasses in existing high-level waste melters.	1.5.2.4.3

Title	**Scope**	**WBS#**
Develop Data and Models for Salt Accumulation in Melters	The loading of many waste glasses are limited by the need to avoid salt accumulation in melters. This includes Hanford low-activity waste and high-level waste, and the Defense Waste Processing Facility high-level waste. The sites have conservative limits on waste loading because the accumulation of salt cannot be effectively predicted. If salt accumulation can be reliably predicted then the loading of these wastes can be increased by removing conservatism. This task will develop methodologies to effectively predict and/or avoid salt accumulation in the melters as functions of key feed and processing parameters.	1.5.2.5.1
Formulation Development for Sulfate Limited Hanford Low-Activity Waste/Defense Waste Processing Facility High-Level Waste	Many current Hanford low-activity waste glasses are limited by salt accumulation. The fraction of these glasses limited by salt will increase substantially if caustic management is effective. Salt accumulation is promoted by SO_3, Cr, F, and Cl, and will significantly reduce the life of components within the melter. For the Defense Waste Processing Facility high-level waste, SO_3, as well as Cl and F also pose processing and glass formulation issues. This task would use the testing and modeling data from the salt accumulation modeling effort to formulate and demonstrate high loaded glasses for Hanford low-activity waste and the Defense Waste Processing Facility high-level waste.	1.5.2.5.2
Formulation Development for Sulfur Limited Hanford High-Level Waste	Many current Hanford high-level waste glasses are limited by salt accumulation in the melter. The fraction of these glasses limited by salt is not known due to uncertainties in sulfur split factors in washing and leaching of the sludge and the amount of sulfur that can be tolerated. This task will use the testing and modeling data from the salt accumulation-modeling task to formulate and demonstrate high loaded glasses for Hanford high-level waste.	1.5.2.5.3
Develop Advanced Characterization Methods for Low-Activity Waste Glasses	A majority of currently projected Hanford low-activity waste glasses are limited by chemical durability. However, the key test being used to screen (and limit) glasses for chemical durability and is subject to high uncertainties. The result of the high uncertainties is an inability to achieve higher waste loadings. This task will evaluate possible test methods and compliance strategies that will allow for lower uncertainties in determining the chemical durability of the low-activity waste glass and therefore allow for higher loadings.	1.5.2.6.1
Formulation Development for Alkali Limited Hanford Low-Activity Waste	Most current Hanford low-activity waste glasses are limited by chemical durability due to high alkali content. This activity would use the testing and modeling data from the high alkali glass modeling effort (08.1.5.2.6.2) to formulate and demonstrate high loaded glasses for Hanford low-activity waste.	1.5.2.6.3

Title	**Scope**	**WBS#**
Denitration process for Bulk Vitrification	The nitrate component imparts some limits on the effectiveness of the bulk vitrification process. Removal of nitrates from the bulk vitrification feed will give several key advantages: 1) the volume of molten salt and potential transport to the refractory walls would be greatly reduced, 2) the primary mechanism for sulfate coalescence and will increase the amount of sulfate that could be treated in the bulk vitrification glass, 3) Tc volatility will be reduced if the nitrates are not present in the bulk vitrification feed, and 4) the quantity of off-gas and amount of NOx generated during melting would be reduced. This task will evaluate the potential improvements to the bulk vitrification process by feed pretreatment and make recommendations on possible technologies to consider.	1.5.3.1.1
Bulk Vitrification Reusable Lid	The current bulk vitrification lid is designed to be disposed of with each box. The lid is a surface where Tc might condense and remain in the disposal package but not immobilized in glass. Although it is difficult to estimate the extent of the deposition until full-scale tests with Tc are conducted there is risk, that disposal of the lid will fail to meet regulatory and environmental objectives. A reusable melting lid with disposal box covers would reduce the risk of failure and may allow for increased plenum temperatures that would increase production rates and increase the amount of waste treated in each box. This task will develop and test the basic concept of replaceable lids at engineering scale.	1.5.3.1.2
Bulk Vitrification Advanced Refractory System	The current design for the bulk vitrification includes more refractory/insulation volume than is available for waste glass. Reducing the quantity of refractory while maintaining the metal box integrity during the relatively short melt duration would significantly reduce the number of bulk vitrification boxes that would need to be produced to treat a specific quantity of waste. Even a modest refractory volume decrease would result in a significant cost savings. This task will evaluate refractory materials and designs that can improve the efficiency of the bulk vitrification process while reducing the technical risk of molten salt penetration into the refractories and refractory failures.	1.5.3.1.3
Bulk Vitrification Optimized Control Instrumentation	Early bulk vitrification tests have shown that instrumentation is critical to the proper operation of the system. On-line instrumentation would allow the bulk vitrification process to be optimized. This task will seek to improve sensors for several key areas in the process: 1) in-line dryer moisture monitor, 2) in-line dryer pellet size sensor, 3) near line feed verification system, 4) dryer and/or melter feed load cell system, and 5) off-gas control sensors.	1.5.3.1.4

Title	Scope	WBS#
Advanced Bulk Vitrification Glass Formulations	The glass formulation for bulk vitrification is based on the initial use of Hanford soil as the main source of glass forming components and a single waste tank composition with minor variations. Glass formulation improvements can 1) extend the applicability of bulk vitrification to a broader range of Hanford wastes, 2) increase waste loading based on planned use of glass forming chemicals replacing soil, and 3) reduce technical risks caused by iron, ionic salts, and salt accumulation. This task will develop advanced glass formulations to improve the breadth and cost effectiveness of bulk vitrification while reducing technical risks.	1.5.3.1.5
Alternative Bulk Vitrification Concepts	The current bulk vitrification system has some challenges to overcome in order to meet the Hanford low-activity waste processing requirements. If bulk vitrification fails to overcome the challenges, an alternate bulk vitrification technology will be necessary for supplemental low-activity waste treatment at Hanford. For an alternate bulk vitrification system, a simplified Waste Treatment Plant low-activity waste type melter with larger melt surface area and moderately higher temperature capability can be deployed. The glass discharge will be into bulk vitrification type containers instead of the Waste Treatment Plant low-activity waste canisters. The feed and off-gas systems will be similar to those for Waste Treatment Plant low-activity waste. The alternate bulk vitrification and Waste Treatment Plant low-activity waste will both be able to share technology improvements and operator experience from either facility. This task will develop and test the concept for alternate bulk vitrification.	1.5.3.1.6
Steam Reforming as an Alternative Supplemental Technology for Hanford Low-Activity Waste	Bulk vitrification is a relatively low technical maturity process (compared to Waste Treatment Plant) and therefore carries risks. In addition, bulk vitrification is not well suited to immobilization of volatile and semi-volatile components. The use of fluidized bed steam reforming to treat the surplus low-activity waste into a mineralized waste from would also accommodate the treatment of sulfates, chlorides, and fluorides associated with the vitrification off-gas and could be a useful backup technology for bulk vitrification. This task will develop and demonstrate the use of fluidized bed steam reforming to generate aluminosilicate minerals from surplus Hanford low-activity waste.	1.5.3.1.7
Hanford I and Tc Management Study	The management of I and Tc at the Hanford site is a key issue for program optimization. The Tc and I are to some extent liberated from the waste evaporation and glass melting. They may be recycled or disposed of as secondary waste. The leachability and mobility of the long half-life isotopes control the integrated disposal facility performance assessment making their fate critical. This task will evaluate the range of Tc and I partitioning to the various streams a Hanford and make recommendations of options for optimizing their management.	1.5.3.2.1

Title	Scope	WBS#
Alternative Feed Strategies	The Defense Waste Processing Facility Chemical Processing Cell will become the limiting step once Modular Caustic Side Solvent Extraction Unit/Actinide Removal Process is implemented due to significant increases in the water content of those feeds. Additionally, technologies that increase Defense Waste Processing Facility melter throughput cannot realize there potential without improvements in the Chemical Processing Cell process. This task will develop and test alternative Chemical Processing Cell strategies to reduce processing time. These technologies will allow for the implementation of the Modular Caustic Side Solvent Extraction Unit/Actinide Removal Process and melting rate improvement technologies.	1.5.3.2.2.1
Secondary Waste Forms for Tc-99 and I-129	Thermal treatment systems are planned for treatment of tank wastes throughout DOE. These treatment systems generate low-activity secondary waste streams. The primary sources are off-gas treatment streams from the thermal processes. These streams typically contain volatile and semi-volatile radionuclides (e.g., Cs-137, Tc-99, and I-129) and Resource Conservation and Recovery Act contaminants of concern (e.g., Hg). Due the volatility of some of the components, recycling the effluents to thermal treatments is not a practical. Therefore, a means to immobilize the secondary wastes for disposal must be developed. This task will evaluate potential treatment processes for secondary wastes at the major DOE sites, select the most promising technology (ies), and perform the necessary testing and demonstration to allow for site adoption. The results of implementing such a technology include the reduction of environmental impact from these wastes and the reduction in risk of performance assessment failure.	1.5.3.2.2.2
Melton Valley Storage Tanks Treatability Study	The Melton Valley storage tank waste is currently planned to be immobilized in cement and disposed of as transuranic in the Waste Isolation Pilot Plant. Refinements are necessary to meet the waste acceptance criteria for disposal in the Nevada Test Site. This task will conduct a treatability study to determine the range of cement and fly ash that would produce a flowable, self-leveling grout, with no free water after 24 hours, and maximize the waste loading while meeting the Nevada Test Site Waste Acceptance Criteria.	1.5.3.2.3
Chemical Durability Test Methods for Secondary Waste Forms	Methods for predicting the chemical durability of secondary waste forms are necessary to demonstrate that the waste forms can meet regulatory requirements. Performance criteria for immobilized secondary waste have not generally been defined. This activity will develop test method and rate laws to predict the releases of key components (e.g., Tc and I) in a disposal facility. The results will be used to support secondary waste form development and qualification across the DOE complex.	1.5.3.2.4

Title	Scope	WBS#
Develop Models for High Sodium Waste Glasses	A majority of currently projected Hanford low-activity waste glasses are in sufficient alkali concentration to be limited by chemical durability. As waste loading increases, the need for significantly improved predictive models becomes critical. Current models for test responses of such glasses are limited in composition range due to insufficient data and subject to relatively high uncertainties (error bars of more than an order of magnitude). This task will collect data and develop models for broader composition regions and reduced prediction uncertainties. This will allow for a significant increase in the loading of Hanford low-activity waste in glass.	1.5.2.6.2
Develop Vitrification process for Idaho National Laboratory Calcine High-Level Waste	The treatment option currently planned for Idaho National Laboratory calcined high-level waste is to package and dispose in the geologic repository. There is a risk that this form will not be acceptable for disposal. To primary alternatives to direct disposal have shown some promise – vitrification and hot-pressing. This task will develop and demonstrate a vitrification process for making a glass/glass ceramic waste form from Idaho National Laboratory calcined high-level waste. If successful, this process will give alternative treatment options for Idaho National Laboratory calcine.	1.5.3.3.1
Develop HIP process for Idaho National Laboratory Calcine High-Level Waste	The treatment option currently planned for Idaho National Laboratory calcined high-level waste is to package and dispose in the geologic repository. There is a risk that this form will not be acceptable for disposal. To primary alternatives to direct disposal have shown some promise – vitrification and hot-pressing. This task will develop and demonstrate a hot-pressing process for making a ceramic/glass ceramic waste form from Idaho National Laboratory calcined high-level waste. If successful, this process will give alternative treatment options for Idaho National Laboratory calcine.	1.5.3.3.3
Processing and Performance Properties of Cementitious Waste Forms	Operation and composition variations impact the processing and performance properties of cementitious waste forms. A series of constraints must be met simultaneously over the range of expected variations to ensure processable cement with that complies with regulatory and program requirements. This task will evaluate the impact of key variables on the processing and product quality of salt stone. The resulting models will be used to optimize the parameters of Savannah River salt stone processes to achieve significant improvements in loading and lower the technical risk of failed batches.	1.5.3.5.1

Title	**Scope**	**WBS#**
Long-Term Performance of Cementitious Waste Forms and Materials of Construction	Degradation mechanisms of cementitious barriers and waste forms are not fully understood and have not been field and laboratory-tested. Current models and design activities rely on data from vendors, literature, and simple tests. This task will investigate the fundamental mechanisms of cementitious degradation include: 1) experiments for long-term accelerated degradation with lab and field tests, 2) oxidation and leaching rates and mechanisms evaluation, 3) evaluation of sulfate reaction rate kinetics, and 4) curing techniques and time impacts tests. These laboratory and field test data will provide Performance Assessment modelers and design engineering with a toolbox of properties, including long-term performance data that can be used for enhanced processing of waste forms, design of future vaults, and improve performance assessment defensibility.	1.5.3.5.7

Appendix D
Proposed Fiscal Year 2008 Funding Portfolio by Work Breakdown Structure

1.1 Improved Waste Storage Technology

Task Title	Performing Organization	Funding Level
Rheological Modifiers and Wetting Agents	***Pacific Northwest National Laboratory (PNNL)*** ***Savannah River National Laboratory (SRNL)***	***$150K***

Scope: To increase processing rates and decrease melt times, DOE waste treatment plants plan to remove significant fractions of water from their high-level waste slurries prior to vitrification. However, at many high solids loadings the rheological properties including yield stress and viscosity may make mixing, transporting, and processing these materials difficult. This task will test select additives that can be mixed with waste to reduce the rheological properties to enable processing at these higher solids loadings.

Remote Monitors Development **Florida International University *(FIU)*** *****

Scope: To design, develop, test, and deploy technology solutions for critical high-level waste monitoring needs at DOE sites. The effort on this task is focused upon the final fabrication of the Solid-Liquid Interface Monitor, which will be shipped to Hanford for full-scale testing in fiscal year 2008 in Hanford's Cold Test Facility. A design and installation report was provided to Hanford for final engineering review in fiscal year 2007. The Solid-Liquid Interface Monitor design has been approved by Hanford and FIU in completing fabrication of an enclosure to surround the monitor. Testing in fiscal year 2008 and will be followed by high-level waste tank deployment during fiscal year 2009.
[* indicates that separate funding estimates were not available as this plan was finalized]

Engineering Studies of Innovative Technologies to Increase Tank Space ***FIU*** *****

Scope: The objective is to test and evaluate technologies and strategies that directly impact limited waste storage space at Hanford. S-109 modeling - Earlier, FIU developed a 3-D model to predict Cs breakthrough curves for Tank 241-S-109 as it is retrieved to provide feed for the Demonstration Bulk Vitrification System at Hanford. During fiscal year 2008, FIU will continue to refine the model and perform additional simulations as sites needs dictate. Plutonium - Disposition - FIU will assist with thermodynamic modeling to identify optimum conditions to achieve selective oxidation of chromium while leaving other high-level waste elements (such as plutonium) in the reduced precipitated state. In-Line Solids Monitor Development - The objective is to design, fabricate, and evaluate in-line solids concentration monitor for the waste transfer lines at Hanford. During fiscal year 2008, FIU will finalize the design of the monitor and fabricate a prototype for cold testing in a typical Hanford Valve Pit mock-up at FIU.

Caustic Recycle and Secondary Waste Support, FIU will continue to provide support to the Hanford site with issues related to the caustic management and secondary waste treatment. [* indicates that separate funding estimates were not available as this plan was finalized]

Evaluation of High-Efficiency Particulate Air Filter Performance under Upset Conditions ***Mississippi State University (MSU/ICET)*** ***$200K***

Scope: The final barrier separating workers and the environment from sources of radionuclides or heavy metals is often high-efficiency particulate air filters. DOE currently employs high-efficiency particulate air filters in a variety of applications. Limited research has been conducted that evaluates high-efficiency particulate air filter performance under conditions that are below, but approach the safety basis described for the filters. Relevant conditions will include high temperature, high relative humidity, and high mass loading concentrations, wet aerosol, and smoke simulation challenges.

1.2 Waste Retrieval Technologies

Task Title	Performing Organization	Funding Level
Pipeline Unplugging Technology Qualification	***FIU and NuVision Engineering (NVE)***	*******

Scope: The objective is to qualify (test and evaluate) pipeline unplugging technology for deployment at the DOE sites. Although technology demonstrations on five pipeline-unplugging technologies carried out in fiscal year 2000 provided insight into the unplugging mechanism, additional testing in a controlled environment is needed to correlate and predict process variables such as pipeline pressure thousand of feet downstream from the point of application. The two technologies deemed best for unplugging high-level waste lines (NVE erosion technology and AIMM Technologies, Incorporated's, Hydrokinetic TM technology) are being tested more rigorously in order to assess their application to removing plugs in high-level waste transfer lines up to 19,000 feet from access points. In fiscal year 2007, NVE demonstrated an approach to unblocking cross site transfer lines on a relatively large scale. Staffs from both the Office of River Protection and the Waste Treatment Plant witnessed the testing and have made recommendations as to how the testing can be improved to be more representative, and applicable to transfer lines across the complex. In fiscal year 2008, it is proposed to take on board these comments and take this testing to the next stage prior to potential 'hot' deployment on an abandoned Hanford pipeline in fiscal year 2009.
[* indicates that separate funding estimates were not available as this plan was finalized]

Retrieval Requirements/Knowledge Center	***SRNL PNNL***	***$150K***

Scope: Technologies for retrieval, cleaning, sampling, etc., have been deployed on a tank-by-tank basis across the complex with very little synergy and sharing of detailed information to assist with future development activities. A team approach utilizing commercial components in an integrated system is needed to efficiently and effectively deploy technologies for waste retrieval. A team of technical experts will collect and manage a database for waste retrieval technologies and lessons learned and utilize it to develop requirements and future technology gaps.

Improved Engineering for Retrieval and Closure	***NVE***	***$1,875K***

Scope: Many high-level waste tanks contain obstructions that limit the effectiveness of sluicing by creating "shadow" areas that the sluicing stream cannot reach. This often results in more material being left in the tank than is technically necessary. Under this project a modified sluicing nozzle will be designed, fabricated, and demonstrated which can be deployed through a small riser yet have an additional degree of freedom to facilitate spraying around obstructions. Also, variable depth sampling of the waste forms in the Hanford double-shell tanks is required to support characterization of waste in support of tank and transfer operations as well as to meet Resource Conservation and Recovery Act permit conditions. Previously, a conceptual design for a nested array fluidic sampler to support feed sampling for the Waste Treatment Plant was developed, this project will use this earlier design as a starting point to develop and demonstrate a multi-depth sampler for use on double-shell tanks at the Hanford site. Finally, Savannah River is investigating dilute-chemistry acid cleaning of high-level waste tanks. After the bulk of the waste is removed from a tank, the remaining solid residue is dissolved with dilute oxalic acid. To increase the efficacy of the process, stirring the in-tank solution can be performed to help ensure that fresh acid is contacting waste residue. This project will fabricate and test a fluidic mixing system to support this process as well as providing a system that can supply a jet of cleaning solution to far-reaching regions of the tank, thereby improving the final end state of the tank.

C Farm Tank Chemistry Neutral Network Development	***MSU/ICET***	***$100K***

Scope: Chemistry representations used in the Hanford Tank Waste Operations Simulator rely on wash and leach factors as opposed to direct, solid-liquid equilibrium, and thermodynamic calculations. An evaluation of the feasibility of upgrading the chemistry representation indicated that a neural network model was preferable. Initial neural networks were developed; this effort will expand the model to address various options for retrieving C Farm Tank wastes.

Design, Construction and Commission of Engineering Scale Test Tank Facility for Radioactive Waste Processing Facilities — ***NVE*** — ***$737K (carryover)***

Scope: Retrieval and treatment of legacy radioactive wastes and tank closure activities across the DOE complex generally require the construction and operation of major new facilities with significant capital and operational cost. The overall objective of this project is to design, build, and commission an engineering scale-test tank facility as a resource to use on projects across the DOE complex to develop and demonstrate tank mixing, pumping, retrieval, sampling, and other equipment needed for waste storage, processing, and retrieval projects. The facility will incorporate a test tank with a 20' diameter and optional 10', 15', or 20' depth which will enable large scale testing, troubleshooting and system development and prototyping to be undertaken in a 'rapid response' manner.

Demonstration of an Innovative Technology for Retrieval of K-Basin Container Sludge Simulant — ***NVE*** — ***$67K***

Scope: As part of the continuing Hanford site restoration, K-Basin sludges have been containerized prior to treatment and ultimate disposal. Each container consists of a number of chambers which slope to the base where there is outlet connection. The baseline approach to waste retrieval was to pump sludge from a manifold arrangement connecting all of these outlets. However, following a DOE Technology Readiness Assessment, it was decided that the approach was not sufficiently developed or mature and that other options should be investigated. In this project, NVE is conducting trials using a proven technology from the United Kingdom to demonstrate the ability to retrieve the sludge from the top of the containers as a more mature approach to sludge retrieval.

Review of Technologies and Approaches Used for Retrieval of Waste from Tanks — ***NVE*** — ***$200K***

Scope: This project will conduct a 'Lessons Learned' review on tank waste retrieval projects across the complex to address items such as the selection process adopted, strengths/limitations of a given technology, and technologies from other industries that may be applicable or adaptable to tank waste retrieval within DOE. The overall objective is to develop a searchable technology database that can be used to help identify the best available technology for a given task by taking into account relevant factors which can be gained from past experience. It is also envisioned that the review may identify 'technology gaps' in retrieval technologies which could form the basis for future technology development and demonstration efforts.

Enhanced Chemical Cleaning — ***SRNL*** — ***($500K in carryover)***

Scope: A test program will be conducted to identify alternatives to the baseline 8 weight percent oxalic acid Chemical Cleaning technology for sludge heel removal and further understanding of the chemistry involved with the most promising sludge heel removal methods. One promising alternative to bulk oxalic acid cleaning has already been identified which utilizes dilute oxalic acid (typically =1 weight percent) and a destruction technology to reduce the remaining oxalates. Other Chemical Cleaning technologies considered may involve oxalic acid or other acids at various concentrations, but will differ in fundamental ways from the baseline (8 weight percent) and dilute oxalic acid/oxalate destruction treatment methodologies already identified. The specific areas needing further study include criticality safety, understanding of corrosion rates, and the neutralization of the re-precipitated sludge. A test with real waste may also be necessary. The potential Chemical Cleaning technologies will be ranked and the top alternatives will be tested with sludge simulants. The most promising alternative technologies will then be evaluated for benefit, deployability, and system impacts against the baseline 8 weight percent oxalic acid process. The preferred alternative technology will be selected for further study.

1.3 Enhanced Tank Closure Processes

Task Title	Performing Organization	Funding Level
Strategy for Handling of Closure of Ancillary Systems	***SRNL***	***$100K***

Scope: In-tank characterization of residual waste both from a volume and chemical/radionuclide content is difficult and subjective. This will become even more of a challenge as ancillary systems are closed. Determining the amount and content of waste that is trapped inside pump, coils, and lines will be extremely challenging. An effort will be initiated to develop a set of tools and methods for characterizing the amount of residual waste inside pumps, coils, and transfer lines. Industry and complex-wide experiences to date will be utilized.

Task Title	Performing Organization	Funding Level
Long-Term Performance of Cementitious Waste Forms and Materials of Construction	***SRNL NIST and NVE***	***$950K***

Scope: A modular approach will be used to develop the set of integrated simulation tools that will predict the hydraulic properties and chemical stability of the radionuclides and cement matrix phases, release fluxes of constituents in response to variable boundary conditions (infiltrating water flux, chemical corrodents known to impact cementitious materials, and events that impact the integrity of the entire structure) over relevant time periods. The level of engineering detail needed to execute the tools will be flexible and based on the requirements of the analysis (e.g., scoping assessments, engineering approximations, detailed evaluations). The simulation tools will be developed based on existing capabilities and software, including STADIUM, LeachXS, CEMHYD3D, GoldSim, and ANSYS. These tools will be integrated by an object-oriented computational framework. The tools will be accessible by a graphical user interface on a desktop computer with network access to supporting computational platforms, when needed. These individual modules will ultimately predict the longevity, durability, and degradation of user-identified cementitious barriers due to chemical and physical properties and environmental stresses. NVE is supporting this effort by providing a comparative insight into the United Kingdom approach to these issues, as well as developing and conducting experimental approaches to help validate the modeling being performed.

Remediation and Closure of Cooling Coils in Large Tanks	***NVE***	***$300K***

Scope: During fiscal year 2007, NVE conducted a feasibility study of alternative tank closure options for Type I tanks at the Savannah River Site. The work focused on identifying cutting technologies and approaches, which could be safely and cost-effectively deployed into tanks to cut and, if necessary, remove sections of cooling coils to both aid waste retrieval and to limit flowpaths for contamination through the coils. The follow-on scope in fiscal year 2008 will develop a better understanding of the total cost, schedule, and budget issues associated with addressing the technical challenges identified in fiscal year 2007. The objective of the fiscal year 2008 scope will be to downselect two favored options for large scale demonstration and then to develop detailed cost information on each prior to a large scale demonstration in fiscal year 2009.

Development of Alternative Approaches to Tank Remediation	***NVE***	***$150K***

Scope: The most common current approach to tank remediation relies upon retrieval of the bulk waste followed by heel retrieval and eventual grouting of the tank in place. Experiences to date have shown that the majority of time, cost, and effort has to be dedicated to addressing the final 20 percent or so of this process. An alternative approach would be to retrieve as much waste as possible from the tank, encapsulate the remaining waste using grout, excavate around the tank and cut out and dispose off-site both the remaining steel shell and the concrete 'pancake' of grouted waste. In this project, NVE will begin to explore this option in more detail by taking into account technical feasibility, cost and regulatory hurdles.

1.4 Next Generation Pretreatment Solutions

Task Title	Performing Organization	Funding Level
Advanced Mixing Models	***SRNL PNNL***	***$150K***

Scope: To accomplish mixing in large tanks, plant operations typically run mixing pumps for extended durations which limits pump life and extends schedule durations. This project will use computational fluid dynamics to develop models for large tanks to determine mixing time required to achieve homogeneity would increase pump life and short process times.

Improved Strontium and Actinide Separations	***SRNL***	***$150K***

Scope: The throughput associated with alpha and strontium removal at Savannah River is dependent on the removal kinetics. This project continues work on improving the sorbent technology and will develop of advanced sorbents for replacement/supplement of monosodium titanate. The planned work includes simulant and actual waste testing to demonstrate performance of revised sorbents.

Rotary Microfiltration — ***CH2MHill (CH2)***, ***SRNL*** — ***$500K (\$1125K carryover)***

Scope: At-tank processing will require solid/liquid separation technology. The rotary microfilter is a very promising technology. This project will complete design and construction of rotary microfiltration system for applications at Savannah River and Hanford. Task is to perform an actual waste filtration. Using carryover funds, work will examine purchasing a new unit with currently identified improvements and examining the efficiency of those improvements. Additionally, testing will be performed to support the rotary microfilter for process Savannah River dissolved salt.

Sludge Mass Reduction — ***SRNL*** — ***$500K***

Scope: Increases in the amount of sludge mass stored at Savannah River could increase the total amount of mass that must be processed through the Defense Waste Processing Facility, increasing the cost and duration of high-level waste processing. This project will perform actual waste tests to demonstrate the sludge mass reduction process. Also, provide revised glass model for leached sludge.

Fractional Crystallization — ***CH2***, ***SRNL*** — ***$2000K***

Scope: Fractional Crystallization is being examined as a supplemental pretreatment alternative. Bench scale testing has shown Fractional Crystallization to provide sufficient cesium decontamination. This project continues the development and will complete pilot scale demonstration of fractional crystallization for cesium removal.

Treatment Legacy Organics for Tank 48 (Wet Air Oxidation Pilot Testing) — ***SRNL*** — ***$400K (\$1000K carryover)***

Scope: Tank 48 at the Savannah River Site contains an organic-laden waste that does not have a defined treatment path. Steam reforming is being pursued as a primary option. This project will develop the backup technology and perform pilot scale testing and actual waste testing for Wet Air Oxidation treatment of tetraphenylborate containing waste in Tank 48 at Savannah River.

Near-Tank Cesium Removal — ***Parsons*** — ***$480K***

Scope: Technology demonstration to provide a portable, modular, shielded, near-tank system for removal of cesium from Hanford tank supernates and dissolved saltcake by fiscal year 2012, well before the Waste Pretreatment Facility is presently scheduled to be available in fiscal year 2019. Once the cesium is removed, the low-activity waste stream can be vitrified. The Phase II technology demonstration is based upon the elutable (re-usable) ion exchange process using the Spherical Resorcinol Formaldehyde resin also planned for cesium removal in the Waste Pretreatment Facility. Successful deployment of this technology will also provide a pilot plant opportunity for the Waste Pretreatment Facility ion exchange technology. After cesium removal, the decontaminated tank farm wastes are likely to be suitable for processing in the low-activity waste melters or alternative immobilization processes.

Continuous Sludge Leaching ***Parsons*** ***$280K***
Scope: The Continuous Sludge Leaching process uses a continually stirred reactor operating at around 90^{o} Celsius in a batch or semi-batch process, blended with additional sodium hydroxide, to remove aluminum from high-level waste sludges at Hanford; the Continuous Sludge Leaching is meant to dissolve the recalcitrant Boehmite phase of aluminum. Parsons' design then uses cross-flow filtration operating at the leaching temperature to separate the reduced volume of high-level waste sludge from the aluminum-laden liquid stream. Following cesium separation using a separate process (where required) the aluminum-laden stream could then be disposed at on-site facilities as low-activity waste, and the reduced volume of sludge can be vitrified as high-level waste. The objective of the Continuous Sludge Leaching project is to develop an easily deployable near-tank system for removal of aluminum from radioactive sludge currently stored in liquid waste tanks at Hanford. Parsons believes that the Continuous Sludge Leaching process requires minimal technology development, and can be ready for deployment at the Hanford site, as soon as the Phase II demonstration test has been completed.

Caustic Recycle ***Ceramatec*** ***$1500K***
Scope: These tasks are designed to enhance the development of an electrochemical system for the recovery of sodium hydroxide from the Waste Treatment Plant ion exchange column effluent. Tasks for fiscal year 2008 will examine the use of a tubular electrode design, electrochemical cell sensing of specific electrolyte concentrations, and additional testing at very high sodium hydroxide concentrations. This work directly addresses issues identified in an External Technical Review.

Small Column Ion Exchange ***ORNL*** ***$1988K***
SRNL ***(Carryover)***
Scope**:** The need for in-tank cesium removal exists at the Savannah River site. Resin selections between cesium strontium actinide and rotary microfiltration have identified some technical risks. Current existing funds will be used to reduce these risks. Task include improved understanding of cesium removal at very low cesium levels, reduced volume of nitric acid in the column eluate, understanding the radiation stability at very high radiation doses, and performance of an actual waste test using Savannah River actual waste.

Support for High-Level Savannah River Salt Disposition Alternatives ***MSU/ICET*** ***$400K***
Scope: Major needs in the Savannah River tank farms are dictated by the desire to separate actinides and cesium from salt wastes permitting the processing of the high activity waste fraction in the Defense Waste Processing Facility and stabilization of the lower activity waste as saltstone. Current progress involves the pilot-scale testing of the Caustic Side Solvent Extraction

process wherein solids re-precipitation and emulsions formation has been observed within the contactors and in wash and scrub liquors; additional evaluation of the simulant used for this testing will be performed.

In addition the processing of sludge (caustic addition to Batch 5) to reduce the fraction of aluminum routed to the Defense Waste Processing Facility is scheduled for fiscal year 2008. It is expected that aluminum-rich supernatants will be processed in the same manner as salt waste. The downstream implications of mixing the aluminum-rich supernatant with fractions from salt waste retrieval and other streams such as the Defense Waste Processing Facility recycle will be studied.

1.5 Enhanced Stabilization Technologies

Task Title	Performing Organization	Funding Level

Enhanced Waste Loading	***CUA***	***$500K***

Scope: Increase the range of high-level waste glass formulations to cover a broader range of wastes and at a higher loading and throughput. Glass formulations for the Hanford Waste Treatment and Immobilization Plant and the Defense Waste Processing Facility will be studied.

Crystal Tolerant Glass Formulation	***PNNL***	***$250K***

Scope: The loading of high-level waste in glass is currently limited by liquidus temperature (T_L) or temperature at 1 percent crystal ($T_{1\ percent}$). A method of high-level waste glass formulation that allows for significant increases in waste loading while not increasing the risk of melter failure would decrease the life cycle cost. This task will develop the data and formulations necessary for adopting the new glass formulation method that allows significant crystals in current glass melters without increased risk of melter failure.

Steam Reforming to Treat Hanford Low-Activity Waste	***URS-WD***	***$2940K***

Scope: To provide Advanced Remediation Technologies Phase II funding for the fiscal year 2008 projected expenses for THOR Treatment Technologies, LLC, Parsons, and AREVA. An additional amount for the fluidized bed steam reforming simulant to be prepared by THOR Treatment Technologies, LLC, as stipulated in the contract for Government Furnished Material is provided.

Cold Crucible Induction Melter	***AREVA***	***$2092K***

Scope: The Cold Crucible Induction Melter has the potential to be a retrofit replacement of the Joule Heated Melter technology currently installed at the Defense Waste Processing Facility using lessons learned from the retrofit of the Joule-Heated Melter at Marcoule, France, currently scheduled to complete in fiscal year 2010. Extensive testing in France has resulted in the decision by the French Atomic Energy Commission, the French government equivalent of DOE, to adopt the Cold Crucible Induction Melter technology for use in their high-level waste vitrification facilities in Marcoule and La Hague, France. Deployment of the Cold Crucible Induction Melter technology offers several potential advantages over the current Joule Heated Melter technology including: 1) higher operating temperatures that support higher waste loadings resulting in fewer canisters produced; 2) glass pool stirrer that ensures homogeneity of the glass; 3) longer melter life based on the cold shell "skull" created on the melter interior surface that prevents erosion and corrosion of internal structure; and 4) replaceable key ancillary equipment.

Direct Analysis of Sludge Receipt and Adjustment Tank Contents Using Laser Induced Breakdown Spectroscopy ***ICET*** ***$250K***

Scope: To accelerate Defense Waste Processing Facility melter operations, the Defense Waste Processing Facility at the Savannah River site needs techniques that can directly analyze Defense Waste Processing Facility Sludge Receipt and Adjustment Tank product. The direct analysis results will be used to determine the appropriate amount of frit to be combined with the sludge in the melter. An appropriate direct analysis method will be developed to monitor the acceptability of the Slurry Mix Evaporator product.

Review of Saltstone Process and Integration of Lesson Learned from United Kingdom Experience ***NVE*** ***$150K***

Scope: The Saltstone Process at Savannah River forms a major part of the long-term stabilization of waste at the site. In order to meet long term site remediation objectives, the reliability and throughput of the plant needs to be significantly improved over current operational experience. In addition, the protocol for waste characterization needs to be reviewed in order to meet regulatory requirements. Working in partnership with its sister company Waste Management Technologies, NVE is conducting a review of the Saltstone Process and facility, as well as documenting lessons learned and the United Kingdom approach to regulation on plants of a similar functionality.

Note: Funding levels in this appendix are estimates only and include funding from a number of sources.